Oregon Lighting Market Assessment

Energy Trust of Oregon Lighting Market Assessment Project

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Submitted to:

Energy Trust of Oregon

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1. EXECUTIVE SUMMARY

This study uses existing market research, interviews with industry experts, formal surveys of market actors, and comparisons with previous studies to create a 'snapshot' of the current state of the Oregon commercial and industrial lighting market. This study follows on from, and uses many of the same methods as, an assessment of the northwest lighting market conducted by the Northwest Energy Efficiency Alliance (NEEA) in 2000.

This study finds that energy-efficient lamps and ballasts, and especially lighting controls, have become much more widespread in the previous decade, across all commercial and industrial building types. Lighting power densities (LPDs) and energy use intensities (EUIs) have been reduced. However, these reductions have been offset by increases in building square footage, so the total amount of electricity used for lighting has remained approximately constant over the same period, i.e. no overall progress has been made in terms of energy use reductions.

The major changes to the market are as follows:

- "High Performance T8" (HPT8), introduced approximately five years ago, now makes up 25% of the market for new fluorescent lighting, and Energy Trust has played a major role in educating and transforming the market for these lamps and ballasts. New Federal requirements will make HPT8 mandatory by July 2012, at which point Energy Trust will no longer be able to provide incentives for this technology. We do not recommend that HPT8 incentives be discontinued immediately, but Energy Trust should consider for how much longer they should be provided (especially in new construction) and should consider what technologies or approaches may replace HP T8 as being eligible for incentives.
- Lighting controls have been adopted very rapidly by the market since 2002, and the quantitative data analyzed in this study suggests that the reduction in energy use due to controls may be as much as the reduction due to LPD changes over the past decade. Market actors have a fairly high degree of confidence in the performance of controls, which may be due in part to Energy Trust's recent focus on controls. Although there are no fundamentally new types of controls becoming available, the recent introduction of lower cost wireless controls may soon open up a large retrofit market for controls if costs are brought down to the right level. Although incentive programs are unlikely to help reduce these costs, they could speed up the introduction of wireless controls once the price is within range.
- However, controls require more education on the part of the designer and installer to achieve successful design, installation, commissioning and continued operation. Energy Trust should continue to work with trade allies to maximize effectiveness of the controls that are being installed (i.e., extend the "Year of Controls" effort), and should consider working together with lighting controls manufacturers to enhance the effectiveness and reach of training.

- Due to new Federal rules, most T12 lamps will no longer be sold after July 2012. Because T12 ballasts mostly cannot be directly retrofitted with T8 lamps, many buildings will be retrofitted with either new ballasts or new luminaires in the years and months leading up to and beyond 2012. Because T12s still account for 17% of the existing lighting market, this will create a large opportunity for energy savings, and for Energy Trust to influence how the market responds to this change. If end-users or lighting services companies undertake to simply change T12s "one for one" for new, more efficient T8s, many spaces may be either overlit or underlit, and savings may be missed even though the new luminaires are more efficient than the old ones. Similarly, if opportunities to install controls are not taken, savings will be missed. Trade Allies are likely to be a valuable resource in optimizing lighting in spaces in which T12 changeouts will occur, and in proactively identifying those spaces as far in advance of 2012 as possible.
- Similarly, the new Federal rules will require more efficient (halogen IR) incandescent lamps to be used, rather than regular PAR lamps or A-lamps. There is a similar danger that if facilities managers change their old lamps for new lamps, they will choose lamps of a similar wattage to what they had previously, and will therefore be overlighting their spaces and failing to achieve savings. Because lamp changes for these lamp types are mostly done by the end-user's own staff rather than by a contractor, the Trade Allies may not be able to help in the majority of cases, and some other outreach, possibly directly to large retailers or via utilities to small retailers, may be effective. Self-ballasted CMH lamps are becoming widely available in a variety of wattages, and Energy Trust should consider whether and how to transform the market (especially the retail market) toward these lamps or toward LEDs.
- Although LPDs and EUIs have come down in retail lighting as much as (or more than) in other building types, actual installed LPDs (in aggregate) are still less than are allowed by Code. This is not the case with other building types, and it suggests that the potential exists for significant savings by tightening code requirements for retail.
- T5 has become the dominant lamp type for new construction in warehouses and industrial buildings, displacing high intensity discharge lamps. This is appropriate given its high efficacy and its photometric suitability for the task, but high output T5 (T5 HO) is also commonly used, and is less efficient than regular T5, so Energy Trust should review the use of T5 HO and consider whether regular T5, HPT8 or newer, more efficient HID lamps can be encouraged where possible.
- Many members of the trade ally network are highly proactive in encouraging their clients to conduct lighting retrofit projects, and become involved in the choice and layout of light fixtures, but most trade allies have not received formal training in lighting design (e.g., LC certification or IESNA "ED" courses), which might help them to fulfill this role more effectively, or even to offer additional levels of service to their clients. Because, according to the market actor survey, trade allies receive much of their training from equipment manufacturers, it may be effective for Energy Trust to work with manufacturers to develop or deliver training.

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MEMO

Date: April 1, 2010
To: Board of Directors
From: Philipp Degens, Evaluation Manager
Spencer Moersfelder
Subject: Staff Response to the 2009 Oregon Lighting Market Assessment

The Commercial and Industrial Oregon Lighting Market Assessment provided very timely information. Updating the market conditions to take into account major changes in codes and standards as well as adoption of various lighting technologies is crucial for Energy Trust to plan and redesign programs. The study shows that lighting in the C&I market still provides a significant untapped regional energy efficiency resource that Energy Trust can target.

The phase out of T12s in 2012 and the new high performance (HP)T8 baseline should be seen as an opportunity that requires advanced planning. Energy Trust programs have anticipated some of these changes by including the new baselines in our cost-effectiveness tests for the effected years. The programs are currently developing (and will continue to develop) new offerings that can provide cost effective energy efficiency with the new baseline. One example is a prescriptive 25-28 watt T8 offering with low ballast factor ballast.

Energy Trust sees that increasing the expertise of the supply chain is a necessary component of any effective market-based strategy for lighting retrofits. Installation and commissioning of controls as well as easy-to-implement lighting design are viewed as important components in continuing education offerings. Energy Trust programs will continue to provide the lighting contractor network with training opportunities as well as developing presentation, workshops , seminars and other materials that can keep lighting contractors aware of new energy efficient technologies and approaches. . We are discussing with CEE and NEEA the possibility of a coordinated regional or national effort built around standard layouts and training for advanced lighting retrofit.

Energy Trust was also viewed by many of the lighting market actors to have had a significant impact on the market adoption of HP T8 technology. Energy Trust is taking steps in developing a market transformation model that may allow Energy Trust to claim market transformation based savings for its influence on market acceptance and thus (in proportion to it's share of the US) on the Federal standard. The model will also collect baseline data that will help support market transformation efforts for the next generation of lighting technologies.

In the area of new construction the 2010 Energy code has addressed most (if not all) of the study recommendations. Lighting power densities have been significantly decreased and lighting control requirements have increased.

The study shows that light emitting diode (LED) technology is still at the initial phases of market adoption with little to no penetration in most applications. Energy Trust is monitoring this market and supporting the Energy Star LED fixture specification. As cost effective applications enter the market Energy Trust is providing incentives first at a custom project basis and then as a prescriptive measure.

2. INTRODUCTION

This study is a 'snapshot' of the current state of the Oregon commercial and industrial lighting market. Where possible, it also compares the current state of the market to data from previous years, most specifically with the Lighting Market Assessment conducted by the Northwest Energy Efficiency Alliance (NEEA) in 2000.

For this study, HMG summarized existing market research, interviewed industry experts, conducted a formal survey of market actors, and ultimately compared these results with previous studies including the NEEA Lighting Market Assessment from 2000, the NEEA Commercial Building Stock Assessments, and the NW Council regional models. We also compared these results with changes in the Oregon Nonresidential Energy Code over the same period.

2.1 Study Goals

The goals of this study are fourfold:

1. To describe the market structure, product flows, baseline sales (by major technology), baseline design and O&M practices, and market penetration of lighting energy efficiency products and services.
2. To analyze how the Energy Trust programs have interacted with and influenced the market and to determine the market actors experience with Energy Trust.
3. To help Energy Trust to assess its influence in transforming the market for select lighting technologies.
4. To inform changes in Energy Trust program design and direction of current measures

2.2 Study Approach

This study used two approaches to explore the Oregon lighting market:

1. Primary Research

   Primary research was conducted though a formal online survey of market actors. The goal of the Market Actor Survey is to describe the products, methods and services offered in the C&I lighting market, to identify any effects that may be due to Energy Trust programs. These results will help Energy Trust to identify barriers and opportunities both in terms of current programs, and in terms of future program options. The methodology and process of this survey are discussed in depth in Section 4.1 of this report. The final survey guide is found in Appendix A—Market Actor Survey Instrument .

2. Secondary Research

Secondary research consisted of a quantitative review and summary of market data from existing reports and surveys. The findings are discussed in detail in Section 3.2.

2.2.1 Relationship to NEEA 2000 Lighting Market Assessment

The NEEA 2000 Lighting Market Assessment played a key role in this study. In an effort to offer updated data on aspects of this well documented study, we placed emphasis on creating a condensed version of the 2000 survey, asking similar questions and utilized a similar sampling methodology. The ultimate goal was to be able to compare these 2009 findings for the Oregon region with the NEEA 2000 assessment of the Northwest regional market. In comparing these two studies we hope to have provided Energy Trust with a clear idea of *how* the market has changed and why it is changing. Ultimately we hope that Energy Trust can take this data and begin to discern the role and impact of their programs and other market interventions had to do with these changes.

There are, however, a few key differences between this study and the NEEA 2000 Study. Most importantly, the NEEA study examined, in detail, the structure of the lighting market. These structures have remained the same today (2009). Thus, the previous study (NEEA 2000) should be consulted by a reader who is seeking complete understanding of the lighting market in Oregon.

Further discussion of how the Market Actor Survey results relate to the NEEA 2000 study results can be found in the analysis section of this report (Section 3.2).

3. REVIEW OF ENERGY TRUST LIGHTING PROGRAMS & CODE REQUIREMENTS

This report includes a review of Energy Trust's C&I programs with an emphasis on lighting incentives and services, to provide the reader with sufficient context to understand Energy Trust's role in the lighting market, and relationship to its Trade Ally Network.

3.1 Overview of Energy Trust Programs

Energy Trust of Oregon's programs are administratively divided into two areas—Business Energy Solutions and Home Energy Solutions. Within those two areas, individual programs are run by various contractors. For commercial and industrial buildings, the assignment of contractors to building types is shown in Figure 1.

	Multifamily[1]	**Commercial**	**Industrial**
Existing buildings	CSG	Lockheed Martin and Evergreen Consulting	Evergreen Consulting and RHT
New buildings	PECI	PECI	PECI

Figure 1. Assignment of Program Contractors to Building Types

In addition to the administration of the programs themselves, Energy Trust employs Evergreen Consulting to manage the Lighting Trade Ally Network, which provides educational and administrative support for the contractors and distributors who take part in the programs, and encourages them to take advantage of all available incentives. This is a regional effort, and Bonneville Power also contributes to Evergreen's work with the Network. Note that Evergreen's contractual arrangements vary between programs; they are directly contracted to Energy Trust under the industrial program (Production Efficiency) but are contracted via the program implementer for other programs.

When customers inquire about incentives and enroll in programs, the administrative program structure is not evident to them, i.e. they do not know the name of the program they are applying for. Instead, on the Energy Trust website they enter their building type and new/existing construction, and are then given step by step instructions about how to enroll, along with relevant forms and contact numbers.

There are five Energy Trust programs involved in the C&I lighting market. They are:

- Existing Buildings (commercial renovation)

[1] In multifamily buildings, only common area lighting is eligible for C&I incentives

- New Buildings (commercial new construction)
- Production Efficiency (industrial renovation)
- Home Energy Solutions (multifamily renovation)
- Efficient New Homes (multifamily new construction)[1]

3.1.1 Eligibility

Energy Trust lighting incentives are available for all types and vintages of buildings. Projects must be located within Portland General Electric or Pacific Power service territories.

3.1.2 Incentives

Projects can qualify for up to $500,000 per site, per year, or up to 50% of project costs, whichever is lower. This total includes both Energy Trust incentives and tax credits from the BETC.

Note that multifamily projects are eligible for incentives regardless of simple payback, and must complete verifications requirements. Otherwise the incentives offerings are identical to commercial and industrial buildings.

Energy Trust offers free building assessments in multifamily buildings. Also, during the verification phase of the program, the program installs up to eight 15- and 25-watt CFLs in each multifamily unit for free.

Standard Incentives

Standard dollar amounts are offered, which vary by fixture type and wattage. Standard dollar amounts are also offered for various types of lighting controls.

New construction projects that claim Standard Track incentives and also achieve the ENERGY STAR building performance certification are eligible for $2,000 to $30,000 per project. Various additional incentives are available for buildings that meet LEED criteria.

[1] As of 2010 multifamily buildings will be included in the Existing Buildings and New Buildings programs.

Fixture type	New	Existing
T8 or T5		
T8 fluorescent (electronic ballast, replace T12, 2-8ft or U Shape)		✓
T8 or T5 lamp (electronic ballast, no more than 4 lamps)[1]	✓	
High Performance T8 (no more than 4 lamps) [2]	✓	
Pendant & Wall Mounted Indirect Fluorescent (T8 or T5)[3]	✓	
High Bay (T8 or T5)[4]	✓	
CFL		
Replace incandescent (2-8ft or U Shape)		✓
Electronic ballast (UL listed, hard-wired, CF 7-56+)	✓	
HID (Replace Incandescent or Mercury Vapor, Metal Halide, <175 watts)		✓
Exit Signs		
LED or Cold Cathode or Electro Luminescent or Self-luminous		✓
Photoluminescent	✓	✓
Lighting Controls		
Dimmable Electronic Ballast[5]	✓	✓
Occupancy Sensor (wall switch[6], fixture or ceiling/wall mount)	✓	✓
Daylight Controlled Dimming (fluorescent)	✓	
Occupancy Controlled Hi-low switching (fluorescent or HID)	✓	

Figure 2: Energy Trust Program 2009 Prescriptive Lighting Incentives

1 New Buildings Program (NB) specifies that luminaire efficiency must be ≥ 72% for parabolic fixtures or open bottom luminaires ≥ 80% for pri smatic lensed luminaires and luminaire efficiency should be tested per IES standards.

2 NB specifies that the fixture must include a high performance 48" T8 lamp with a not-to-exceed nominal wattage of 32W and ballast system that is listed on the CEE qualifying product list.

3NB specifies the fixture must have an electronic ballast, no more than 3 lamps, indirect or indirect/direct light distribution, overall luminaire efficiency ≥ 77%, and luminaire efficiency should be tested per IES standards. Incentives are offered in 4ft sections.

4 NB specifies that the fixture must have an electronic ballast electronic ballast, T5 3 or more lamps, T8 4 or more lamps, overall T5 luminaire efficiency ≥ 88%, T8 ≥ 81%, and fixtures must be installed in a high bay area with a min ceiling height of 15ft.

5 Dimmable electronic ballasts are specified in NB as fluorescent hard-wired, passive infrared and/or ultrasonic technology, control a min. of 100 Watts, units with non-resetting manual "ON" override not eligible, units required by code not eligible. There is no fixture specification for the existing building programs (Production Efficiency, Multifamily Home Energy Solutions)

6 Wall switch occupancy sensors are only offered an incentive in the existing building programs.

Custom Incentives

Custom incentives for lighting projects vary between new construction and retrofit. These incentives have fluctuated over time. The incentives listed here are for the 2009 program year. For new construction the incentive is currently $0.10/annual kWh, while for existing buildings the incentive is currently 35% of the total approved project cost, not to exceed $0.17/annual kWh (or $0.20/annual kWh for industrial projects). Incentives may be reduced for projects with payback periods of less than one year.

For existing buildings to qualify for a custom incentive, the energy savings must be at least 25% of the current energy use for lighting equipment (note that the eligibility requirement for Energy Trust's program is the same as for BETC).

Technical Assistance

Up to $25,000 (or 50% of total project cost, whichever is lower) is available for technical assistance. In addition, commissioning incentives are available for up to $40,000 per project.

Business Energy Tax Credit

The state of Oregon offers a Business Energy Tax Credit (BETC) on lighting equipment purchases. To claim the BETC credit, new construction lighting projects must be 10% more stringent than the state energy code, and retrofit projects must be 25% more efficient than the existing lighting. Lighting projects must have a simple payback of one to fifteen years.

3.2 Summary of Program Activities

A summary of Commercial and Industrial program activity, provided by Energy Trust, is shown in Appendix E and Appendix F, respectively.

3.3 State and Federal Energy Code Requirements

3.3.1 New Federal Lamp Efficiency Requirements Taking Effect July 2012

The U.S Department of Energy (DOE) has released new energy efficiency standards for linear fluorescent lamps (not ballasts) and incandescent lamps (DOE 2009). These standards are pursuant to the Energy Policy and Conservation Act (EPCA), and will take effect in July 2012.

In the case of fluorescent lamps, the increase in efficacy created by the standard will be slight in percentage terms (though large in terms of statewide savings because of the number of lamps affected), but in the case of incandescent lamps the standard represents a major gain in efficiency, effectively outlawing basic incandescent reflector lamps.

Summary of the New Standards

We have summarized the changes to fluorescent and incandescent lamp standards separately below.

Fluorescent Lamps

A summary of the new efficacy requirements is given in Figure 3. The new standards for fluorescent lamps will not substantially affect T5 lamps, which already exceed the required efficacies. T12s will mostly be eliminated (following on from the elimination of magnetic T12 ballasts in June 2010), and lower-performance T8s will be eliminated while high performance T8s are retained. The new requirement of 89 lm/W for 4' T8s neatly splits the performance of regular 800-series T8s (approx 88 lm/W (BetterBricks 2004)) from the performance of "high performance" 800-series T8s (approx. 92 lm/W).

Note that the new Federal requirement applies to the *lamp*, whereas the CEE standard (CEE 2009) used by Energy Trust and others to define "high performance T8" applies to the efficiency of the *ballast* (or, optionally, the lamp-ballast system), rather than to the lamp. The CEE standard only requires the lamp to have a certain minimum light output, life, and lumen maintenance.

Lamp type	**Minimum lamp efficacy (lm/W)**
4-foot (T8)	89
2-foot U-shaped	84
8-foot slimline[1]	97
8-foot high output	92
4 foot (T5) low output	86
4 foot (T5) high output	76

Figure 3. Summary of New Federal Requirements for Fluorescent Lamps <=4500K[2] and >25W

Incandescent Lamps

The new standards for incandescent reflector lamps, shown in Figure 4, apply only to line voltage (120V) lamps, not to low voltage (6V) halogen lamps, which already exceed the

[1] It's unclear from the text of 10 CFR Part 430 what lamps are included in this definition.. It may be explained in the Analytical Tool that will accompany the ruling, to be released by DOE "soon" (September 2009).

[2] ttp://www1.eere.energy.gov/buildings/appliance_standards/residential/incandescent_lamps_standards_final_rule.html

new requirements. Note that other lamp types such as mercury HID and metal halide lamps are already regulated and are not mentioned in these revised standards.

Lamp diameter	Minimum efficacy (lm/W)	
	40W lamps	205W lamps
>2.5”	16.0	27.6
<2.5”	13.5	23.4

Figure 4. Summary of New Federal Requirements for120V Incandescent Lamps 40-205W

Likely Effect of New Federal Requirements on the Lighting Market in Oregon

The new efficiency standards for fluorescent lamps cover *lamps only*, not ballasts. And, by technical necessity, the standard only requires a certain minimum lumen output at a prescribed wattage, i.e. it is not a true efficacy requirement, only a requirement for minimum light output. For instance 4’ T8 lamps are required to put out at least 3100 initial lumens (compared to the 2800 lumens that has been typical for 4’ T8 lamps), which means that in retrofit applications the new lamps will simply be giving more light, rather than using less power.

Because the lamps required by the Federal standard will almost certainly be compatible with existing T8 ballasts, people will simply be able to operate these lamps on their existing ballasts, and thus obtain a higher light output rather than energy savings. To obtain savings, they would have to replace their existing ballasts with ballasts that had a lower ballast factor.

Because this ruling does not require more efficient ballasts, it *does not ensure that “High Performance T8” lamp-ballast systems will become the norm*, but it does eliminate some of the worst-performing lamps available on the market currently, including most T12 lamps and some lower-efficiency 4 foot. T8 lamps (i.e. “700 series” lamps).

Because 700 T8 series lamps are seldom used in applications such as offices or grocery stores, lighting practice in these building types will likely be unaffected by the new federal standard. However, where 700 series lamps are more commonly used (warehouses, industrial facilities), the new requirement for 800 series lamps will create a slight increase in performance and a slight increase in price.

Existing T12 ballasts can mostly *not* be fitted with T8 lamps, so many facilities managers will have to change out their T12 ballasts or fixtures. This may create be a significant opportunity for Energy Trust to incentivize those companies to move to the most efficient available ballasts and fixtures, and/or to reduce light levels or add controls at the same time.

In the case of incandescent reflector lamps[1], the effect on the market will be more marked. Only a few products are currently commercially available that will comply with the requirement. Line-voltage reflector lamps will, in practice, need to be of the "infra red coated" (IRC) type to meet the new requirement. Halogen IRC lamps are widely available but at a price premium over regular halogen lamps. More efficient lamp types such as ceramic metal halide, low-voltage halogen and LED are not affected by the new standards.

We therefore believe that most people who currently use incandescent reflector lamps will continue to do so, but will move to the infra-red coated type, with a corresponding 20-30% efficacy improvement over current practice. Moving to infra-red lamps will not require them to change out their lampholders or other equipment, so the potential for Energy Trust to leverage this change for savings is small.

The new Federal standard requires lamps that are *manufactured or imported* to meet these new standards, i.e. distributors can continue to sell their inventory of non-compliant lamps after the effective date of the standard. However, due to the large size and low dollar value of fluorescent lamps, it's unlikely that these lamps will be "stockpiled" in large numbers.

3.3.2 Changes to Oregon Code Between 1998 and 2007

The Oregon Non-Residential Energy Code was developed by the Oregon Department of Energy (ODOE) in 1996

There were revisions to the lighting requirements of the code between 1998 and 2007. Any changes to the Code are likely to have created significant changes in lighting energy use in new construction, so we have compared the Code requirements for these two revisions. The period 1998 to 2007 closely parallels the period between the 2000 NEEA Lighting Market Assessment and this 2009 study. There was also a 2003 revision to the code, but it would not be reasonable to try to determine exactly how much change took place in the market in each of the brief periods 1998-2003 and 2003-2007, so we have considered only the broad 1998-2007 period.

The reason why Code changes achieve statewide energy savings is that they bring the level of practice of "late adopters" up to the level of practice of the majority of the market. Code changes are made possible by developments in technology, and by the lead provided by innovative designers and clients, and by utility incentive and education programs. Code can therefore be said to *follow* and be made possible by the changes already affected by innovators. There are however circumstances in which Code appears to have lead the market, for instance in the adoption of lighting controls, which were very uncommon in Oregon prior to their inclusion in the 1998 Code.

[1] Federal standards will also require higher efficiency A-lamps (as well as reflector lamps) but these are now very uncommon in commercial buildings, and by 2012 are likely to be so uncommon that the Federal standard will have no measurable effect. However, the effect on *residential* lighting will most likely be profound.

Many issues affect the energy savings achieved by Code, including the "naturally occurring" rate of improvement in energy efficiency, and the ability and willingness of designers and purchasers to comply, and the amount of enforcement

Controls Requirements of Code

It is not straightforward to quantify the expected magnitude of energy savings from changes to the lighting controls requirements of code, but this section summarizes the main requirements and the main changes between 1998 and 2007[1].

1998 Code

The 1998 code had requirements for indoor lighting and prescriptive and performance options for demonstrating compliance.

The general requirements for indoor lighting included:

- Accessible Manual switching for all enclosed spaces, and all spaces >2,000sf
- Additional automatic shut-off controls in offices over 2,000sf

The options for automatic shut-off controls in offices included occupancy sensors or dimmers. There were several exceptions to these controls requirements, including:

- lighting for warehouses, parking garages or spaces using less than 0.5 W/sf.
- public areas with switches that are accessible only to authorized personnel.
- lighting for contiguous, single-tenant retail spaces

2007 Code

The 2007 code added several requirements for lighting controls and modified the prescriptive approach. Changes to the lighting requirements included:

- Automatic shut off controls required for *any* space >5,000 sf, in addition to offices over 2,000 sf .
- All offices <300 sf, meeting and conference rooms and all classrooms must have occupancy sensors.
- Automatic daylighting controls are required in classrooms and atriums with window-wall-ratios (WWR) greater than 50% or with skylights. The controls must control only luminaires within the daylit area, be capable of reducing light output by one-half, and provide continuous dimming.

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[1] NEEA conducted an evaluation of code changes and energy savings between the 2005 and 2008 codes due to lighting LPD changes (not including controls) . However, because the Oregon code LPDs did not change during that time, they did not identify any savings. See Non-Residential Energy Savings From Northwest Energy Code Changes 2005-2008, Market Progress Evaluation Report, E09-204 (5/2009), http://www.nwalliance.org/research/reportdetail.aspx?ID=145

Lighting Power Density Requirements of Code

1998 Code

The 1998 Code allowed three compliance methods are:

- Occupancy Method,
- Space-by-Space Method (for additions and alterations)
- System Performance Method

The Occupancy Method set out maximum power density (in Watts/sf) by occupancy type. The power density is calculated for the whole building, so power densities can vary within the building.

The Space-by-Space Method is limited to additions and alterations, and must be calculated and applied to each room.

The System Performance Method is the ASHRAE/IES Standard 90.1 approach which uses a tailored approach for projects that require higher lighting budgets. The higher allowances must be justified by the lighting layout.

Manufacturing use was exempt.

2007 Code

The lighting power density calculation can be accomplished using:

- Tenant Space Method
- Space-by-Space Method

The Tenant Space Method is the same as the Occupancy Method from the 1998 code, but clarifies that it is used either for the whole building or the tenant space being permitted.

The Space-by-Space Method is used if a higher lighting budget is needed and is required for spaces with retail display lighting. The Retail Display Lighting Allowance can only be used in the sales area. This method is similar to the ASHRAE/IES Standard 90.1 approach.

Summary of LPD Changes

Figure 5 shows the LPD changes in some of the Occupancy/Tenant Space categories. The average percentage difference between the 1998 and 2007 codes, calculated line-by-line, is 6%. However, there are many rare building types in which the LPD limit was *increased* from 1998 to 2007, which skew this line-by-line average. Looking only at only the most common space types (in bold) the percentage reduction in lighting power density from the 1998 to the 2007 code is fairly consistent at around 18%.

This improvement of 18% corresponds reasonably well to the “10% improvement” commonly believed to be achieved in every code cycle. The estimate of 18% is conservative for two reasons. First, the value used in the table for 1998 retail is the lowest of three values, as shown in Figure 6. Second, there was no lighting power limits for manufacturing facilities in the 1998 code.

Lighting Power Density (W/ft2)	**2007**	**1998**	**Dif**	**% Dif**
Automotive Facility	0.9	1.2	0.3	25%
Convention Center	1.2	1.4	0.2	14%
Court House	1.2	1.1	-0.1	-9%
Dining: Cafeteria/Fast Food	**1.4**	**1.5**	**0.1**	**7%**
Fire Station	0.8	1.2	0.4	33%
Gymnasium	1.1	1.1	0	0%
Healthcare – Clinic	**1**	**1.5**	**0.5**	**33%**
Hospital	**1.2**	**1.5**	**0.3**	**20%**
Hote/motel	**1**	**1.2**	**0.2**	**17%**
Library	1.3	1.1	-0.2	-18%
Manufacturing Facility, Non-process Areas3	1.3	none		
Motion Picture Theatre	1.2	1.1	-0.1	-9%
Museum	1.1	1.1	0	0%
Office	**1**	**1.2**	**0.2**	**17%**
Parking Garage	0.3	0.3	0	0%
Performing Arts Theater	1.6	1.1	-0.5	-45%
Police Station	1	1.2	0.2	17%
Post Office	1.1	1.2	0.1	8%
Religious Building	1.3	1.1	-0.2	-18%
Retail	**1.5**	**1.7**	**0.2**	**12%**
School/University	1.1	1.2	0.1	8%
Warehouse	**0.8**	**1**	**0.2**	**20%**
Average Difference				6%
Average Difference for Common Bldg Types				18%

Figure 5. LPD comparison between 2007 & 1998

sf	**LPD**
<2000	3.4
2000-6000	2.5
>6000	1.7

Figure 6. 1998 Retail LPD by space size

4. METHODOLOGY

As described in section 2.2, we used two primary methods for obtaining lighting market data: Primary research, i.e. a formal online survey of market actors; and secondary data, i.e. a quantitative assessment of existing data on the market, and a review of Energy Trust's programs. This section describes the methodology for those two elements.

4.1 Market Actor Survey Methodology

This section describes the methodology and process of implementing this survey. Later sections discuss the results of the survey with supporting market data from other research as appropriate. The full survey guide including the questions asked can be found in Appendix A—Market Actor Survey Instrument .

The methodology for the Market Actor Survey involved the following steps:

- Survey Development
- Conduct expert interviews with "top performer" trade allies to review questions from NEEA 2000 study for their continued relevance, and to identify new areas of interest
- Develop draft Market Actor Survey
- Obtain feedback on survey draft from lighting experts
- Develop sample goals for survey
- Administer survey

The questions in the Market Actor Survey were based, to the extent possible, on the questions in the Commercial And Industrial Lighting Market Research Study conducted for NEEA in 2000, so that changes over the intervening years can be clearly identified. Based on the results of the Expert Interviews adapted, removed and add questions to the original survey, based on developments in the market in the intervening decade.

4.1.1 Survey Development

We held a focus group with top performing trade allies from Energy Trust's Lighting Trade Ally Network, as well as program staff from Energy Trust's commercial and industrial programs. The purpose of the focus group was to establish a clear structure for the new Market Actor Survey, to determine which questions from the 2000 survey should be retained, modified or dropped, and which new questions should be added.

When the draft survey instrument was completed, it was sent to expert market actors for review and comments. The expert interview guides and the notes from the meeting of top performing Trade Allies can be found in the Appendices.

4.1.2 Sample Goals

Our goal was to survey 60 contractors, distributors and designers, and to allow the results of this survey to be directly compared with the results of NEEA's 2000 survey, i.e. we intended to create a sample that included the same balance of professions, in which distributors are strongly represented.

The population from which this sample was drawn included 160 unique contact names from Energy Trust's Trade Ally Network (for contractors and distributors), and from a list of non-trade-allies obtained by Energy Trust from the Oregon Labor Market Information System (search by NAICS code), which included 28 lighting designers, 98 electrical engineers, and 434 architects.

The NEEA study was not intended to be a statistically representative sample of market actors, and does not explain why that specific balance of professions was chosen, but it is appropriate for distributors to be highly represented because they have the broadest exposure to the lighting equipment market. Our sample included:

- Contractors (15):
- Contact details obtained from a list of Energy Trust Lighting Trade Ally Network participants (circa. 160 contacts), provided by Energy Trust
- Distributors (30)
- Contact details obtained as above. Note that, according to Evergreen Consulting, the distributors in the Trade Ally Network represent "almost all" the specialist lighting distributors in the state.
- Designers (15)
- Contact details obtained from a list of Oregon business from Info.gov, provided by Energy Trust, categorized by NAICS code based on tax returns. This list included:
- Lighting designers
- Electrical engineers
- Architects

We decided to contact only contractors and distributors on Energy Trust's Trade Ally list for two reasons: First, because the individuals on the list are mostly lighting specialists, and would therefore have a keener understanding of the lighting market than distributors and contractors chosen at random; and secondly because Energy Trust's contractor, Evergreen Consultants, informed us that, in their estimation, *all* the lighting specialist contractors and distributors in the state are members of the Trade Ally network.

The Trade Ally Network includes companies of different sizes, which have had differing degrees of involvement with Energy Trust's lighting projects. Both of these factors can be expected to influence a company's assessment of the lighting market and of Energy Trust's role in it. So to ensure a balanced sample, we stratified the list on two axes as shown in Figure 7—the size of the company (number of employees), and the number of projects it had completed with Energy Trust in 2008.

Involvement with Energy Trust in 2008		Business Size	
Stratum	**Number of projects conducted with Energy Trust**	**Stratum**	**Number of employees**
1	0	1	1-9
2	1-2	2	10-19
3	3+	2	20+
		PNTS	Preferred not to say

Figure 7. Sampling Strata for Trade Ally Sample

Using these strata we created a goal for the sample, based on the distribution of companies within the whole trade ally network. The sample goal is shown in Figure 8. The sample was also intended to achieve the relative proportion of distributors vs. contractor shown above (30:15).

		Business size stratum			
		1	**2**	**3**	**Total**
Involvement stratum	**1**	9	8	5	**22**
	2	2	4	2	**8**
	3	10	2	3	**15**
	Total	**21**	**14**	**10**	**45**

Figure 8. Sample Goal for Trade Allies (Contractors and Distributors)

The final distribution of trade ally responses is shown in Figure 9. The number of responses exceeded the sample goal (59 compared to 45), and the distribution is very close to the sample goal, except that some respondents did not tell us the size of their business.

		Business size stratum						
		1	**2**	**3**	**PNTS**	**Blank**	**Total responses**	**Sample Goal**
Involvement stratum	1	9	6	2	5	3	**25**	22
	2	2	1	2	0	0	**5**	8
	3	12	2	5	3	1	**23**	15
	Total responses	**17**	**7**	**5**	**6**	**10**	**59**	45
	Sample Goal	21	14	10	N/A	N/A	45	

Figure 9. Distribution of Trade Ally Responses to Market Actor Survey

For the "designers", we stratified the sample by business size, but not by profession (architect/designer/engineer) because we had no reason to believe that these three professions would see the lighting market differently. Figure 10 shows the final distribution of designers respondents to the Market Actor Survey, along with the sample goals. We received a total of 16 responses from designers.

		Business size stratum					
		1	**2**	**3**	**PNTS**	**Blank**	**Total responses**
Business type	Architect	0	0	2	0	0	**2**
	Lighting Designer	4	3	1	0	0	**8**
	Electrical Engineer	0	0	6	0	0	**6**
	Total responses	**4**	**3**	**9**	**0**	**0**	**16**
	Goal	5	5	5	0	0	**15**

Figure 10. Distribution of Designer Responses to Market Actor Survey

4.2 Assessment of Quantitative Market Data

We attempted to obtain quantitative market data from three sources:

- Previously published market studies
- The NW Council
- Commercially-available market data

We have analyzed two previous market studies in detail (in addition to the NEEA study from 2000), to pull out data that will allow us to compare current and historical market conditions. These studies are described below. We also analyzed output from the NW Councils' energy consumption model, and compared these model results to other studies, as described below.

We reviewed the availability of commercially-available data on lighting equipment sales in the Northwest as a whole, and Oregon in particular, but we were unable to locate commercially-available studies whose methodology was described in sufficient detail to give us confidence in their methods and findings.

To allow comparisons with the Commercial and Industrial Lighting Market Study published by NEEA in 2000, we have recreated many of the tables and charts in that report using updated (2009) versions of the same data sources, where available. Where relevant, we have also discussed any differences between the 2000 findings and 2009 data.

4.2.1 Baseline Characteristics of Commercial Buildings

Two baseline studies were funded by NEEA and conducted by Ecotope (NEEA 2001 and NEEA 2008), looking at new construction (including additions to existing buildings) between 1998 and 1999, and then between 2002 and 2004. Both studies used a large sample of buildings in the Pacific Northwest (232 and 346 respectively) and collected detailed data on site, so the results have a high degree of validity. 44% of these buildings were in Oregon. Data collection included lamp and fixture types, and lighting power densities. In many cases there are clear changes in the lighting equipment market over this five year period..

4.2.2 Commercial Building Stock Assessment

The commercial building stock assessment conducted by NEEA is based on a combination of site surveys conducted in 2002 (NEEA 2004) and databases from site visits done in earlier studies. A 2007 update(NEEA 2009) incorporates additional site visit data as well as the NEEA new construction baseline study (NEEA 2008). As with the new construction baseline studies described above, surveyors recorded the number of and types of lamps and fixtures, and calculated lighting power densities.

The 2002 site visits covered mainly buildings built in or before 1994 .[1] . Whereas the site visits performed in 2008 covered mainly buildings built before 2001. Many data points were repeated observations of the same buildings at intervals of several years to study rates of demolition, and the frequency and type of lighting retrofits. In each year, sites were selected at random from the previous sample, i.e. no preference was given to recent retrofit projects.

As with any statistical market analysis, no single data source will provide a complete picture of market dynamics. There are two sources of error that affect the accuracy of the

[1] It was assumed that building data that was collected in later years had not changed significantly.

lighting data from these assessments. The first source is created by the change in samples between sampling periods—the buildings surveyed in 2007 may not be the same buildings surveyed in 2002, so reported changes may be due to the inclusion of different buildings. The second cause of error is simply due to small sample size—if the analysis set is reduced to include *only* buildings that were included in both the 2002 and 2007 sample, then the number of buildings is smaller and therefore the error in projecting up to a statewide figure is larger. Error due to small sample size is also an issue when extracting only *Oregon* data from a larger Northwest data set. Because the errors in such surveys are usually due mainly to sampling bias rather than to statistical effects, we have not spent time analyzing the magnitude of statistical errors in depth.

4.2.3 NW Council

The economic forecast team of the NW Council (NW Council) uses the Baseline Characteristics of Commercial Buildings study survey data to model projected energy use in commercial buildings. The data collection process was conducted by the Council starting in 1985. The Council uses commercial building stock data to obtain annual estimate of square footage, and uses lighting power density data gathered from surveys in conjunction with annual statewide energy use figures to obtain annual energy use intensity (EUI) estimates for lighting, broken down by building type. This information is tracked yearly, and is recalibrated to actual gathered data as new survey results become available[1].

As part of the tracking process, the forecast team uses weather data to correct projected electric power requirement figures. Thus, it is possible to extract weather-dependent loads such as HVAC from statewide energy use, to produce an estimate of annual change in *non* weather-dependent loads (such as lighting). However, it is impossible to distinguish changes in lighting power consumption from changes in *other* non-weather-dependent loads (such as plug loads), although lighting is the largest non-weather dependent load, so the NW Council data is probably a good estimate of year-by-year changes in lighting energy use.

Typically their analysis shows a discrepancy between how much power various generation companies sold, and the reported energy use estimates determined from surveys. The NWPCC calibrates the EUI estimates by a factor derived from the relative difference in comparison numbers. The calibrated EUI estimates are the numbers reported in this report.

Although calibrations are performed regularly and data collection is performed by a third-party with no stake in the outcome, some factors affect the reliability of the data. These factors include:

- Local zoning distinctions (e.g. small industrial buildings classified as commercial space)

[1] The most recent of which was the 2002-2004 Baseline Characteristics Study

- Inaccurate reporting of building use when ownership changes (e.g. a building classified as warehouse built in 1990 is used as retail/office space in 2002)
- Where/how energy is being consumed (especially true for power generation facilities near local and state borders).

5. MARKET DATA

5.1 Data Sources

To clarify how this market data study drew on various data sources, Figure 11 provides the date, origin, construction type and region studied for the most important quantitative data presented in this section.

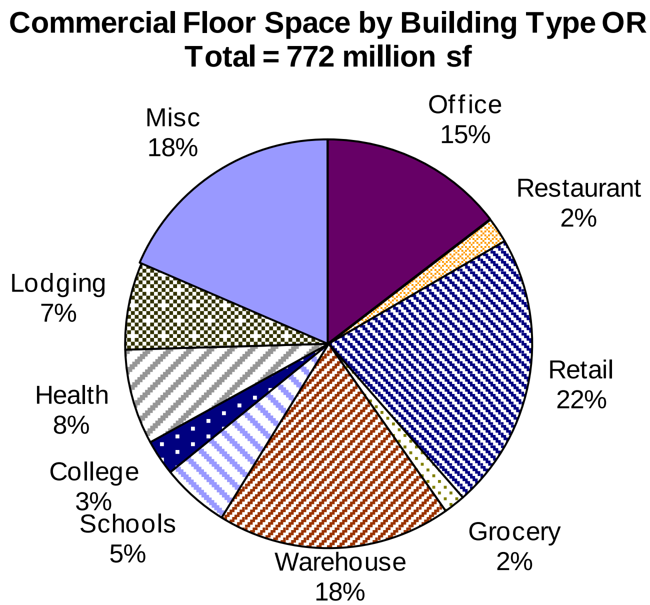
Type of data	Year(s)	Source	New or Existing Construction	OR, PNW, both
Statewide lighting energy use	1995-2005, 2009-2030	Northwest Power and Conservation Council	Existing and New	Both
Lighting power density (LPD)	2002 and 2007	CADMUS (NEEA Commercial Building Stock Assessment)	Existing	Both
	2002-2004	NEEA Baseline Characteristics of the 2002-2004 Non-Residential Sector	New	Both
Lighting energy use intensity (EUI)	1995-2005, 2009-2030	Northwest Power and Conservation Council (calculated)	Existing and New	OR
Installed lamp types and wattages	2002 and 2007	NEEA Commercial Building Stock Assessment	Existing	Both
	2002-2004	NEEA Baseline Characteristics of the 2002-2004 Non-Residential Sector	New	Both
Installed control types	2002-2004	NEEA Baseline Characteristics of the 2002-2004 Non-Residential Sector	New	Both
	2002 and 2007	NEEA Commercial Building Stock Assessment	Existing	Both
Program Savings	2003-2009	Energy Trust of Oregon	Existing and New	OR

Figure 11. Quantitative Data Sources Used in this Study

5.2 Statewide Buildings Populations and Lighting Energy Consumption

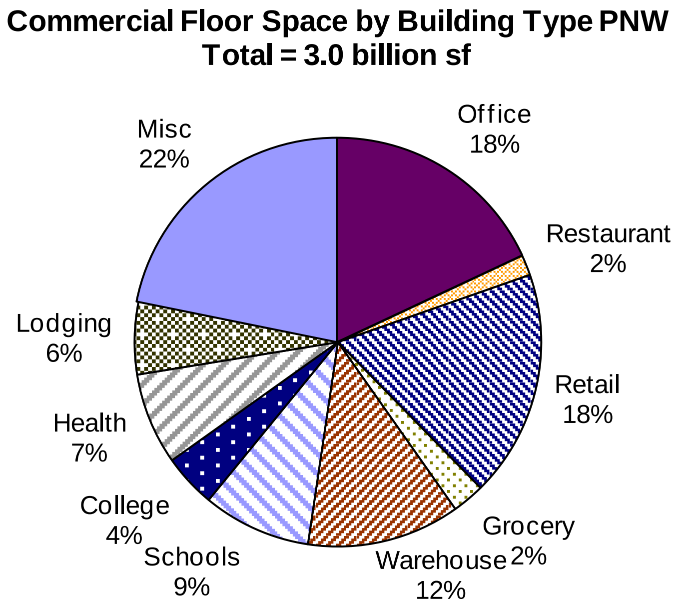
5.2.1 Commercial End-Use Population

The Northwest Power and Conservation Council (NW Council) provides estimates of the amount of commercial floor area in Oregon, using both historical and projected data. This breakdown is based on historical data on lighting end-use intensity combined with projections of total electricity sales. These data are obtained by the NW Council from electric utilities. Figure 12 and Figure 13 show the floor area breakdown by building type for the state of Oregon (OR) and the Pacific Northwest (PNW) respectively. Note that industrial floor area is a subset of “miscellaneous”.



Source: NW Council Commercial Square Footage Estimate

Figure 12. Percent C&I Floor Space by Building Type—Oregon 2009



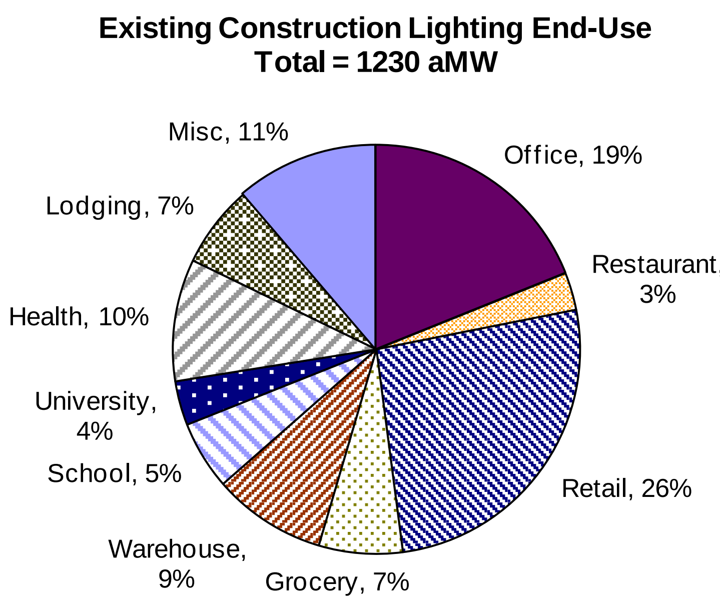
Source: NW Council Commercial Square Footage Estimate

Figure 13. Percent C&I Floor Space by Building Type—Pacific Northwest 2009

The data shows that Oregon is slightly less than 25% of the total commercial building stock in the Pacific Northwest and that Oregon's building stock distribution is slightly, but not significantly different than the PNW. Offices and education (school and colleges) are marginally larger percentages of total PNW commercial floor space than Oregon floor space, while retail and warehouse space are larger percentages of Oregon stock than in the rest of the PNW, although these regional differences are not great. These values are not significantly different from those that existed in 2000.

5.2.2 Lighting End-Use by Building Type

The total average lighting energy consumption for the PNW for 2009 is predicted to be 1230 average megawatts (aMW), whereas 2000 had a predicted total lighting energy consumption of 1613 aMW. This equates to a 24% decrease in total lighting energy use over 10 years. The total commercial and industrial floor area in the PNW was 2.5 billion ft^2 in 2000 and is 3.0 billion ft2 in 2009, which means that a rough approximation for the annual lighting energy use intensity (EUI) dropped from 5.6 kWh/ft^2 to 3.6 kWh/ft^2, a 36% decrease over 10 years. This equates to a 16% reduction per four-year code cycle.



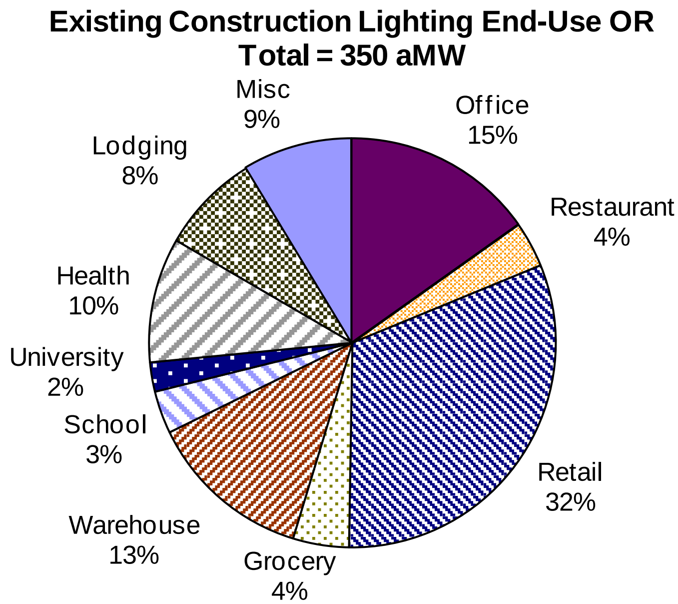
Source: NW Council Electricity Sales Forecast Data

Figure 14 . Pacific Northwest Lighting End-Use by Building Type 2009

Figure 15 shows lighting electricity use in each building type, for all existing commercial floor area in Oregon in 2009. This breakdown is significantly different from the data available in 2000. The lighting percentage for the office building type was 29% in 2000 and has decreased to 19% of the total lighting sales for 2009. Conversely, lighting energy use in retail spaces increased from 20% in 2000 to 26% in 2009. School lighting consumption has dropped from 9% in 2000 to 5% in 2009.

Oregon's total lighting sales are 28% of the total Pacific Northwest lighting sales. Compared to the rest of the PNW Oregon's office lighting is a smaller share of total sales; however retail lighting is a larger share.

Note that an analysis of Energy Trust's own model of Oregon lighting electricity use shows a significantly higher statewide total (560 aMW as opposed to 350 aMW). The Energy Trust analysis shows offices using 37% of lighting energy and retail using 25%. These differences give an indication of the likely margin of error in estimates of lighting energy use, which by necessity are based on limited surveys of real buildings, since lighting energy use cannot be directly measured by the utilities.



Source: NW Council Electricity Sales Forecast Data

Figure 15. Oregon Lighting End-Use by Building Type 2009

Figure 16 shows the scale of Energy Trust's lighting programs compared with statewide lighting energy consumption. It shows historical lighting energy consumption since 1995, which has remained relatively constant, and also shows Energy Trust's claimed savings since 2002 (note the difference in the scale of the y-axes), calculated as a cumulative value, i.e. with each year's savings persisting undiminished into all subsequent years. Energy Trust's programs have cumulatively achieved approximately 120 GWh/yr of savings, compared with statewide lighting energy use of 3000 GWh/yr, i.e. around 4%. Energy Trust does not have a value for the weighted average savings from lighting retrofit projects, but T8-T12 replacement projects, which make up the majority of projects, averaged around 45% energy savings compared to existing lighting, which suggests that Energy Trust's programs have installed lighting in somewhere around 8% of commercial buildings, statewide.

This data also shows that lighting consumption has decreased slightly over the years (2005-2009), though we consider this within the margin of error due to the methods used by NW Council to calculate lighting energy use. ETO program savings are increasing annually.

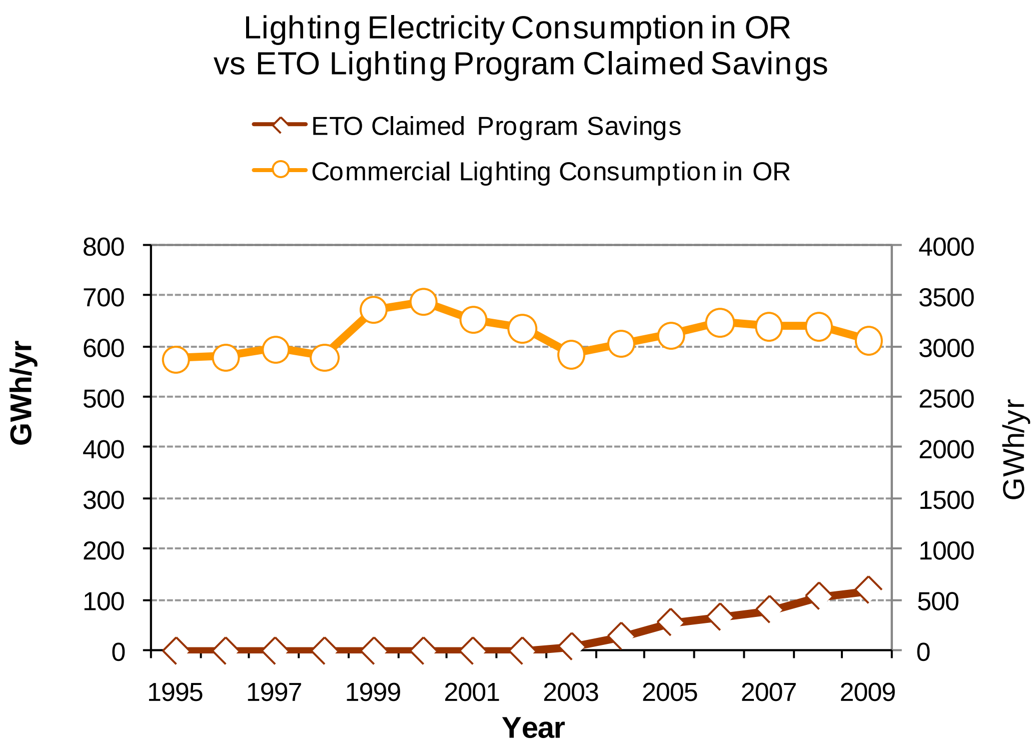


Figure 16. Energy Trust Program Claimed Savings as a Proportion of Statewide Annual Lighting Energy Use

Note that Energy Trust operates in utility territories that represent only 75% of the statewide load, so Energy Trust's savings as a proportion of load are higher when only their own operating territory is considered.

5.3 Ballast and Lamp Types

5.3.1 Indoor Lighting

The lighting market can be segmented by ballast type using data gathered from on-site audits. Note that the "percentage of installed lighting wattage" is not necessarily the same as the "percentage of lighting energy consumption", since this will vary according to the number of hours for which the lamps are run.

The 2002-2004 NEEA Baseline Characteristics report (NEEA, 2008) provides data on installed lamp types in buildings constructed between 2002 and 2004. Figure 17 gives the lamp type breakdown by building type in the PNW, it also shows the market shares for each lamp type, averaged (by floor area) across all building types. This study used a sample of 346 buildings. The installed lighting wattage shown in Figure 17 through Figure 28 are based on site observations, which should be accurate representations of practice in new construction from 2002-2004 in the PNW. Linear fluorescent lighting (LF) has remained relatively constant; however HID distribution has dropped (from 28% to 17%).

Building Type	CFL	Linear Fluorescent	High Intensity Discharge	Incandescent	Other
Assembly	13%	60%	16%	12%	0.0%
College	17%	52%	1%	30%	0.0%
Schools	12%	72%	12%	4%	0.0%
Grocery	1%	69%	17%	12%	0.5%
Health Services	12%	70%	5%	13%	0.0%
Hospital	17%	70%	1%	12%	0.8%
Institution	14%	66%	2%	18%	0.4%
Office	10%	78%	3%	10%	0.0%
Other	5%	73%	17%	5%	0.0%
Residential/Lodging	15%	22%	1%	55%	6.8%
Restaurant/Bar	15%	56%	1%	28%	0.0%
Retail	5%	55%	24%	15%	0.4%
Warehouse	1%	35%	61%	4%	0.0%
Average weighted across building type	9%	58%	17%	15%	0.8%
Average from previous (1998) study	5%	58%	28%	10%	0.2%

Source: NEEA Baseline Characteristics of Commercial Buildings Constructed from 2002-2004

Figure 17. NEEA 2002-2004 Baseline Study--Distribution of Lamp Type by Building in New Construction PNW (% of lighting watts installed)

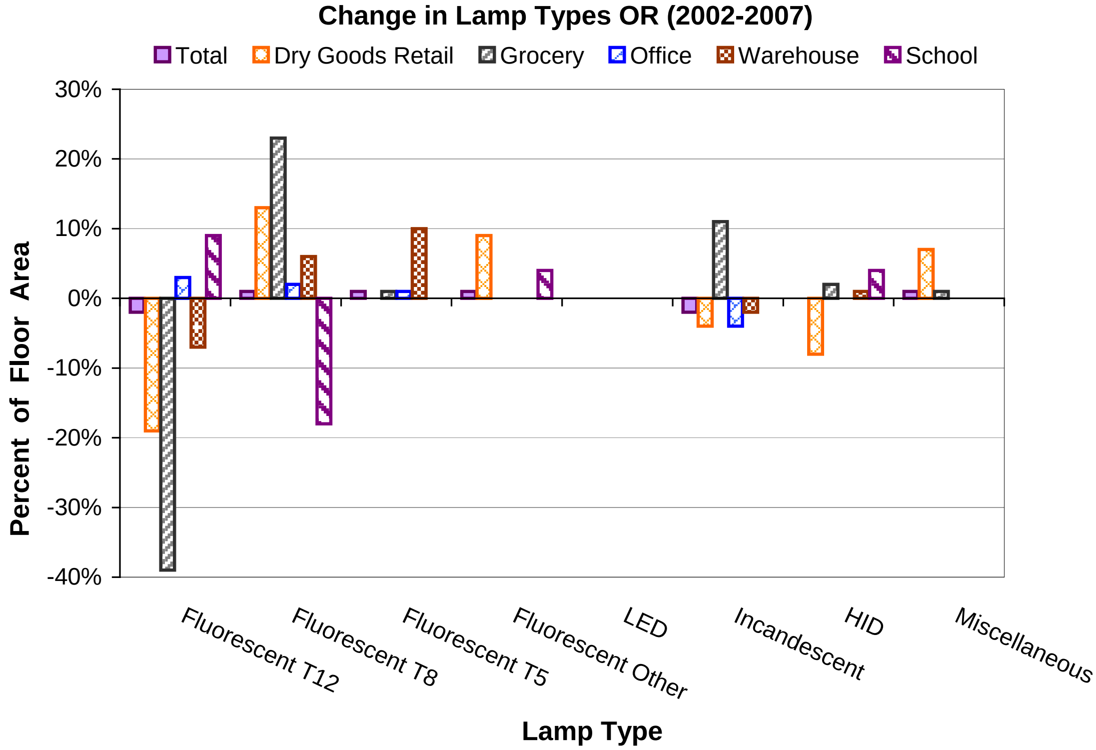
Figure 18 shows the lamp type breakdown for existing construction. Clearly fluorescent T8 lamps are the highest proportion of the wattage for all space types. High performance Fluorescent T8 lamps are not segregated from this data due to the difficulty in distinguishing high performance lamps from standard T8 lamps. Figure 18 shows HID at an even lower percentage (13%), and incandescent continuing to climb (to 18%), while fluorescent is the dominant lamp type. The key takeaway between Figure 17 and Figure 18 is that incandescent lighting is 15% of installed wattage in new construction buildings (between 2002 and 2004) however; incandescent wattage in existing buildings is 18% in 2007. This indicates that while incandescent still consume 1 out of 5 watts (lighting wattage only), in new construction projects incandescent lighting consumes 1 out of 6 watts.

Building Type	Fluorescent	Incandescent	HID	Miscellaneous
Dry Goods Retail	67%	14%	16%	3%
Grocery	67%	12%	19%	2%
Office	92%	5%	2%	<1%
Restaurant	34%	59%	3%	4%
Warehouse	57%	3%	40%	<1%
Hospital	85%	9%	3%	3%
Hotel/Motel	14%	85%	<1%	<1%
Other Health	80%	18%	2%	<1%
Other	60%	15%	22%	3%
School	91%	3%	6%	<1%
University	98%	<1%	<1%	<1%
Vacant	S	S	S	S
Average weighted across building type	67%	18%	13%	2%

Source: NEEA Commercial Building Stock Assessment, 2007

Figure 18. Distribution of Lamp Type by Building in Existing Construction in Oregon, 2007 (% of lighting watts installed)

Figure 19 shows the change in lamp type between the 2002 and 2007 Commercial Building Stock Assessments, plotted by subtypes of fluorescent lamp, for five key building types: retail, grocery, office, warehouse and school. It shows a drastic decrease in fluorescent T12 ballasts installed in grocery, retail and warehouse spaces, and a corresponding increase in fluorescent T8 and T5 lamps. It corroborates the increase in incandescent lamp use shown in Figure 17 and Figure 18; the increase in incandescent lamps may be due to their use in grocery stores, though this is based on data from only 29 stores.



Source: NEEA Commercial Building Stock Assessment

Figure 19. Change in Lamp Types OR 2002 – 2007, Existing Buildings

Figure 20 shows the responses obtained in the Market Actor Survey to the question "In *retrofit* projects, what percentage of all the new fixtures had the following lamp types?". This table is the most recent of all the data sources, because it reflects current practice among Energy Trust's Trade Allies and other market actors. It shows a much lower percentage of incandescent lamps than the older data sources (though this is not surprising given that Trade Allies attempt to install incentivized lamps, and incandescents are not incentivized). It also shows a lower percentage of HIDs—it's notable that in warehouses and industrial facilities linear fluorescents now outnumber HIDs by 4:1. CFLs appear to maintaining a similar prevalence over time, between 5 and 10%. The only building types with more than 20% CFLs are multifamily and institutional buildings, and restaurants.

Note that in the Market Actor Survey there were a total of 179 responses, but many building types received only a handful of responses.

Building type	T8 HP	T8	H5 HO	T5	CFL	Incand -escent	HID	Other	Number of responses
Offices	60%	21%	2%	2%	8%	3%	3%	1%	47
Schools (K-12)	49%	23%	19%	1%	5%	2%	1%	1%	20
Warehouses	24%	2%	49%	3%	2%	1%	19%	1%	49
Grocery stores	69%	10%	10%	10%	0%	1%	0%	0%	9
Assembly	13%	21%	67%	0%	0%	0%	0%	0%	3
College/university	31%	26%	8%	3%	8%	6%	17%	0%	6
Health services	60%	40%	0%	0%	0%	0%	0%	0%	1
Hospital	40%	40%	0%	0%	0%	10%	10%	0%	1
Multifamily residential	12%	14%	0%	6%	36%	16%	16%	0%	5
Industrial	16%	10%	47%	6%	1%	0%	18%	0%	23
Institutional	50%	0%	0%	0%	40%	0%	10%	0%	1
Lodging	0%	0%	0%	0%	9%	80%	10%	1%	1
Restaurant/bar	31%	12%	0%	0%	41%	3%	14%	0%	5
Retail	77%	0%	5%	0%	17%	0%	0%	0%	8
Average	40%	13%	24%	3%	7%	3%	10%	1%	

Source: Market Actor Survey

Figure 20. Lamp Types Used in Retrofit Projects, 2009

Linear Fluorescent Lamps

Figure 21 shows the distribution of lamp types in new construction for linear fluorescent (LF) lighting. T12 lamp use in Oregon declined significantly between 1998 and 2004 (from 10% to 0.6%), while T5 lamp use increased from zero in 1998 to 19% of linear fluorescent wattage in 2004.

T8's percentage of the lighting market remained relatively constant between 1998 and 2004, both in the region and within Oregon. This is not surprising because in 2004 high performance T8 technology had only just been introduced.

There was a strong uptake of high performance T8 in the following few years; Figure 20 indicates that approximately one quarter of T8 lamps being installed in retrofit projects are now high performance.

The 2007 data also shows that despite being almost eliminated from new construction and retrofit projects, T12 still makes up 17% of fluorescent wattage statewide, due to the large number of T12 ballasts that continue to function. This value comes from the large sample in the NEEA Commercial building Stock Assessment so we believe the figure is robust. T12 is used most commonly in dry goods retail, warehouses and non-hospital healthcare buildings.

State	T12	T5	T8	T8 High Performance	Other Fluorescent
Oregon '04	0.6%	19%	79%	2%	0.1%
Region Average '04	2%	12%	84%	2%	0%
Region Average '98	10%	0%	88%	0%	2%

Source: NEEA Baseline Characteristics of Commercial Buildings (2002-2004)

Figure 21. Linear Fluorescent Lamp Market Shares in New Construction, Changes from 1998 to 2004 (% of lighting watts installed)

Building Type	T12	T8	T5	Other Fluorescent
Dry Goods Retail	35%	42%	1%	4%
Grocery	13%	71%	1%	3%
Office	15%	65%	7%	9%
Restaurant	23%	23%	1%	6%
Warehouse	19%	48%	11%	4%
Hospital	1%	69%	4%	19%
Hotel/Motel	6%	9%	0%	19%
Other Health	31%	40%	1%	18%
Other	9%	56%	6%	15%
School	7%	77%	8%	5%
University	0%	73%	5%	20%
Vacant	S	S	S	S
Average	17%	51%	5%	9%

Source: NEEA Commercial Building Stock Assessment 2007

Figure 22. Breakdown of Linear Fluorescent Lamps by Type, Existing Buildings in OR, 2007 (% of floor area)

High Intensity Discharge (HID) Lamps

Figure 23 details the lamps used in indoor HID lighting applications. The overwhelming majority of HID lighting in Oregon (96%) and in the PNW as a whole (77%) is metal halide (HID-MH) lamps. In new construction, HID lamps other than metal halide make up only a small percentage of overall wattage.

Ceramic metal halide lamps (HID-CMH) give an improvement in performance over regular metal halide, but by 2004 had made little inroad into the market. The "Other HID" lamp type represents mercury lamps, which by 2004 had been almost eliminated from the new construction market. Note that Federal regulations have prohibited the sale of ballasts for mercury vapor lamps since 2008, although replacement lamps can still be purchased.

State	Other HID	HID-CMH	HID-HPS	HID-MH
Oregon	0%	3%	2%	96%
Region Average '04	2%	6%	16%	77%

Source: NEEA Baseline Characteristics of Commercial Buildings (2002-2004)

Figure 23. Breakdown of HID Lamps by Type, New Construction, 2002-2004 (% of total HID watts)

Building Type	HPS	Mercury Vapor	Metal Halide	Neon
Dry Goods Retail	20%	0%	75%	5%
Grocery	0%	0%	100%	<1%
Office	4%	8%	88%	0%
Restaurant	S	S	S	S
Warehouse	43%	2%	56%	0%
Hospital	S	S	S	S
Hotel/Motel	S	S	S	S
Other Health	S	S	S	S
Other	<1%	<1%	100%	0%
School	0%	20%	80%	0%
University	S	S	S	S
Vacant	S	S	S	S
Average	18%	1%	80%	1%

Source: NEEA Commercial Building Stock Assessment 2007

Figure 24. Breakdown of HID lamps by Type, Existing Buildings in OR, 2007 (% of floor area)

5.3.2 Outdoor Lighting

Figure 25 shows that 70% of outdoor lighting for C&I buildings is provided by high intensity discharge lamps (HID), and that HID is the dominant source for outdoor lighting for *all* building types. The recent move toward HID for outdoor lighting is corroborated by the fact that the building type with the *least* outdoor lighting is the type “vacant”.

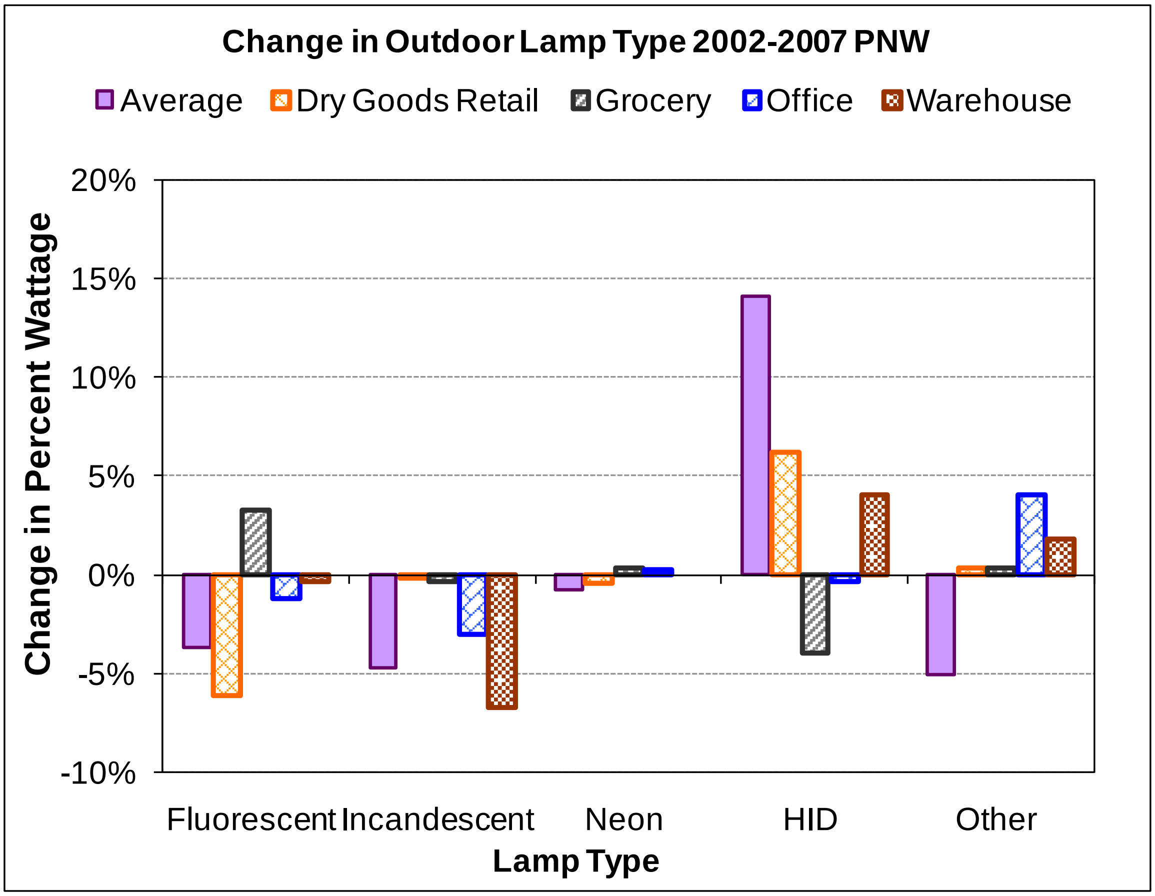
	Fluorescent	Incandescent	Neon	HID	Other
Dry Goods Retail	21%	10%	1%	68%	0%
Grocery	19%	4%	0%	76%	0%
Office	12%	11%	0%	73%	4%
Restaurant	14%	31%	3%	49%	3%
Warehouse	1%	7%	0%	90%	2%
Hospital	4%	3%	0%	86%	7%
Hotel/Motel	13%	14%	1%	72%	1%
Other Health	5%	33%	0%	60%	3%
Other	10%	4%	0%	70%	17%
School	3%	1%	0%	71%	25%
University	6%	1%	0%	93%	0%
Vacant	19%	38%	0%	43%	0%
Average	11%	8%	0%	70%	10%

Source: NEEA Commercial Building Stock Assessment 2007

Figure 25. Breakdown of Outdoor Lighting by Lamp Type, Existing Buildings in OR, 2007

Figure 26 shows the change in outdoor lighting in existing buildings between 2002 and 2007. it shows that the trend for outdoor lighting is in some ways the reverse of the trend for indoor lighting—HID sources have become more popular at the expense of fluorescent. The fact that HID lighting is technically suited for outdoor lighting is probably a major factor in its continued use—HID lighting can provide a great deal of light from a single fixture, and can be more easily focused than fluorescent, which is essential for lighting large outdoor areas.

The magnitude of the changes is quite small—mostly less than 5 percent. This contrasts strongly with the indoor lighting changes which showed much more drastic change, for instance in the reduction of fluorescent T12 ballasts. Incandescent has also become slightly less prevalent over the same period.



Source: NEEA Commercial Building Stock Assessment 2007

Figure 26. Change in Outdoor Lighting Breakdown by Lamp Type 2002-2007

5.3.3 Ballast Types

Figure 27 and Figure 28 detail the ballasts used in linear fluorescent (LF) and High Intensity Discharge (HID) lighting applications.

Fluorescent Ballasts

The virtual elimination of magnetic ballasts is an obvious development between 1998 and 2004, as is the significant increase in the use of dimmable ballasts in the PNW as a whole. However, this increase appears to have taken place mainly in Washington. The percentage of dimmable ballasts remained constant at around 3% in Oregon between 1998 and 2004. The small number of dimmable ballasts in the sample means that there is likely to be a high margin of error in this finding.

The number of high performance electronic ballasts being used in new construction in 2004 was still low, at around 1%, because the technology had only recently been released.

State	Dimmable Electronic	Efficient Magnetic	Electronic	High Performance Electronic
Oregon '04	3.5%	0.5%	95.6%	0.5%
Region Average '04	6.7%	0.9%	91.3%	1.1%
Oregon '98	3.3%	10%	86.7%	0%
Region Average '98	1.8%	14.4%	83.8%	0%

Source: NEEA Baseline Characteristics of Commercial Buildings (2002-2004)

Figure 27. Distribution of Fluorescent Ballast Types (% of Fluorescent watts)

High Intensity Discharge Ballasts

HID ballasts are classified as either probe start or pulse start, and either magnetic or electronic. Both pulse start and electronic operation offer marginal increases in efficiency over regular ballasts. Figure 28 shows that in 2004 the market for HID ballasts was evenly split between probe start and pulse start magnetic ballasts, with electronic ballasts not yet having a significant market share. Note the large number of ballasts that could not be classified, which adds uncertainty to the data.

At the time of writing, HID manufacturers are rapidly introducing new products with both pulse start magnetic and electronic ballasts, so it is likely that the market for these products is changing at a faster pace than can be captured in a quantitative market study.

State	Electronic pulse start	Magnetic probe start	Magnetic pulse start	Unknown
Oregon '04	1.7%	13.5%	17.0%	67.7%
Region Average '04	2.5%	15.8%	18.2%	63.5%

Source: NEEA Baseline Characteristics of Commercial Buildings (2002-2004)

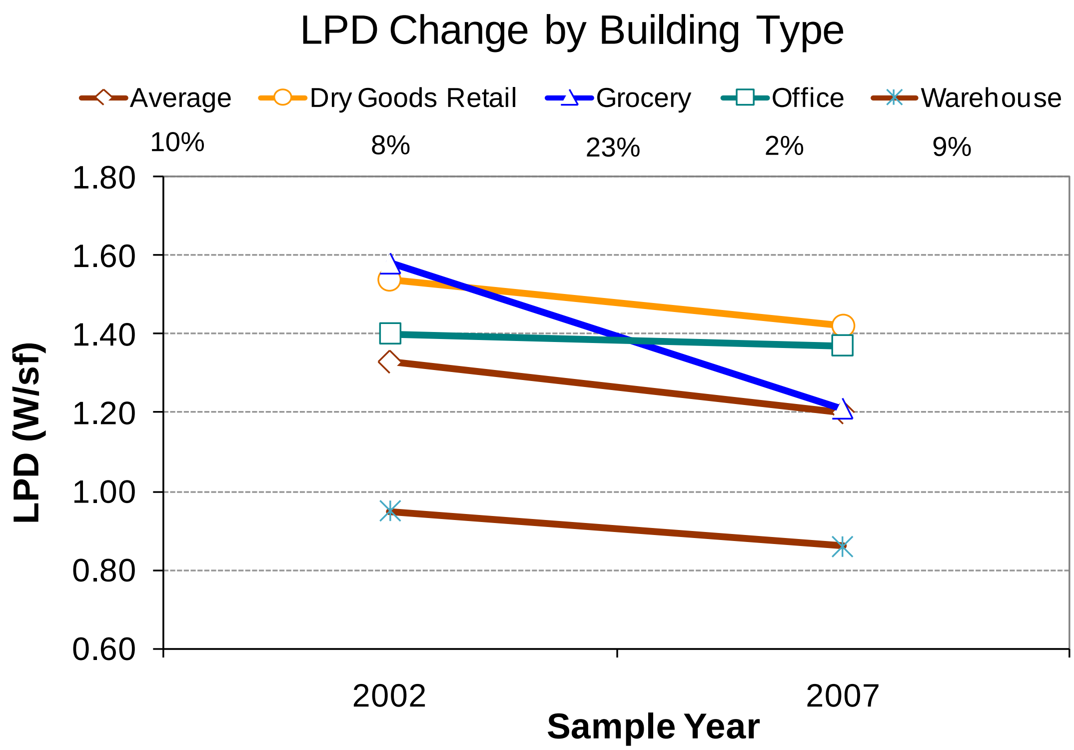
Figure 28. Distribution of HID Ballast Types (% of total HID watts)

5.4 Lighting Power Density and Lighting End-Use Intensity

5.4.1 Lighting Power Densities

Figure 29 shows a general decrease in lighting power density (LPD) between sample years 2002 and 2007. In the Conclusions and Recommendations (Section 6.2) these changes are discussed in the context of other data, including Code.

This data is taken from on-site observations of the same sample of buildings during the two observation years, five years apart, and therefore probably represents the most accurate available data on the relative change in LPD over the period. Grocery stores show the most drastic change in LPD due to the observed change in lamp type. From 2002 to 2007, Grocery space in Oregon reduced fluorescent T12 lamps installed by nearly 40%, and replaced these lamps with mostly fluorescent T8 as well as, possibly, and some incandescent lamps.



Source: NEEA Commercial Building Stock Assessment

Figure 29. Lighting Power Density (LPD) Change in a Consistent Sample of Existing OR Buildings from 2002-2007,

For additional context, Figure 30 shows how the lighting power densities in each building type compared with Oregon Code in force at the same time. It shows that existing building performance was worse than Code in the case of offices, warehouses and schools, which is to be expected since most existing buildings would not be compliant. However, in the case of dry goods retail and grocery the existing buildings actually outperformed Code, suggesting that there may be a significant margin for Code improvements in these building types.

Source	Average	Dry Goods Retail	Grocery	Office	Warehouse	School
2002 NEEA CBSA	1.33	1.54	1.58	1.40	0.95	1.24
1998 OR Code	N/A	1.70	*1.90*	1.20	1.00	1.20
2007 NEEA CBSA	1.20	1.42	1.21	1.37	0.86	1.11
2007 OR Code	N/A	1.5	*1.9*	1	0.8	1.1
Difference between average building and Code (%)						
2002		-9%	-17%	17%	-5%	3%
2007		-5%	-36%	37%	7%	1%

Figure 30. Differences in LPD between Existing Buildings and Code in Oregon, for Key Building Types in 2002 and 2007

5.4.2 Lighting End-Use Intensity

End-use intensity (EUI) is a measure of the energy use per square foot (sf) of floor space per year. The regional studies performed surveys of existing buildings starting in with Bonneville Power Administration (BPA) Nonresidential study of the 1988 building stock. Additional studies were performed by BPA, states and utilities until NEEA began undertaking regional market research, commencing with the 1998 new construction study (Pacific Northwest region: Oregon, Idaho, Montana), and 2002-2004 (new construction Pacific Northwest region) (Ecotope 2001, 2008) and the 2002 and 2007 Commercial building stock studies ..

From these studies and others, the Northwest Power and Conservation Council (NW Council) has constructed a model that both tracks and predicts end-use energy consumption (including lighting) by building type and by state in the Pacific Northwest. From each survey an estimate for EUI is multiplied by the square footage of building stock over the state (and region). This total energy consumed is adjusted annually based on electric utility sales numbers obtained directly from utility generation facilities. The calibrated energy consumption figure is divided by total building floor area across the state (and region) which yields relatively accurate EUI estimates.[1]

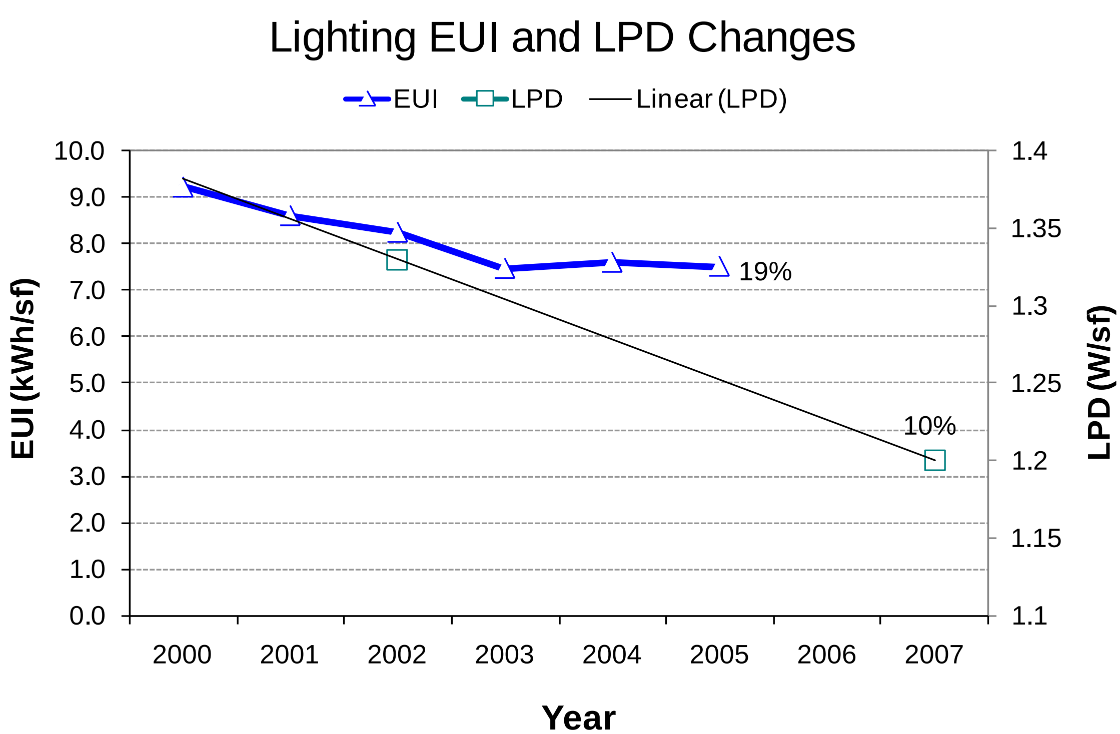
[1] Note that although EUI is a useful measure of energy density that allows for comparison within building type categories, the procedure for estimating this figure is often to use assumptions about lighting hours of use in a given building type, which are often not based on monitored data. Another approach, taken in the NEEA studies, was to calibrate the on-site survey data to electricity billing data for each building, which is likely to be more accurate than simply using an assumption about hours of use, but still introduces a level of uncertainty into the estimate of EUI.

The NW Council model performs additional adjustments to the total energy consumption figure depending on the weather conditions during the survey year. Weather-dependent electric loads include: HVAC systems, plug load heaters and electric water heaters. For example, during a warm year, electricity estimates for water heating are higher than the previous year; these loads are adjusted down to remove any fluctuations that are inaccurate. The result of this modeling process is EUI trends that show year-by-year decrease from each year since Energy Trust was founded in 2001.

Figure 31 shows that NW Council's estimate of Oregon's lighting EUI declined steadily over the period 2000-2005. This reduction in EUI is corroborated by the reduction in installed lighting power density already discussed. Note that the changes are small as a percentage of the total, and that the margin of error in the data is likely to be larger than the reported change in lighting energy use.

The reduction in EUI from 2000-2005 (19%) is larger than the reduction in LPD (10%), which is consistent with the increased use of lighting controls having an effect (over the same period) that is of the same magnitude as the LPD reduction.

The NW Council model does not indicate whether this reduction was statistically significant, but given the large sample size and the consistency of method between the two reports, we believe that it is.



Source: NEEA Commercial Building Stock Assessment 2007, and NW Council Model

Figure 31. Comparison Between Oregon EUI and LPD Values Over Time.

Lighting power density (LPD) and end-use intensity (EUI) both show significant reductions over the past decade. Lighting EUI values are derived from building survey data that has been calibrated with electricity sales data by the NW Council, whereas LPD values are from a sample of buildings observed in 2002 and 2007. Though the LPD sample is not representative, and the lighting EUI data has not been calibrated recently (2002 was last calibration year), both data sets show a similar trend toward reduced energy consumption. The percentages reported in Figure 31 are the changes over 5 years.

5.5 Lighting Controls

Lighting control strategies were in widespread use in *new* construction in the commercial building stock of the PNW by 2004, due to requirements in the 1998 Code. Whereas 1998 averages show that very little new construction space had lighting controls, 2004 data shows that nearly half of all new construction commercial floor space in PNW was controlled by occupancy sensors and over 50% of new construction floorspace in Oregon was occupancy sensor controlled. Note that this change occurs immediately following the requirement in the 1998 Code for automatic shut-off controls in offices.

Multi-level switching, time sweep, lighting EMS and daylighting strategies are all used approximately as frequently in Oregon as in the rest of the PNW region. The use of all these control strategies has greatly increased since 1998.

State	Sweep	Lighting EMS	Daylighting	Occupancy	Multi-level Switching
Oregon '04	34%	32%	18%	53%	38%
Region Avg '04	37%	34%	18%	47%	39%
Region Avg '98	9%	0%	4%	5%	0%

Source: NEEA Study Baseline Characteristics of Commercial Buildings (2002-2004)

Figure 32. Distribution of Lighting Control Strategies in New Construction (% of floor area controlled by particular strategy)

The 2004 baseline study does not show how the use of lighting controls breaks down by building type, but it does provide the following commentary:

> *Occupancy sensor (OS) controls in classrooms, enclosed offices, and other enclosed spaces, are common. Much less common are OS controls in large spaces such as gyms, school corridors, and warehouses even when fluorescent fixtures are installed. However, there are examples of buildings successfully deploying OS controls in these latter spaces. Extending OS use into school gyms and corridors has significant potential energy savings because these spaces are often on extended schedules with long periods of non-use. Warehouse and storage areas are often partially used and may have certain areas that are frequently used while*

another area is totally vacant. In this case, OS and multi-level switching could be combined to greatly reduce the energy use.

Multi-level switching is common and was observed in a variety of applications in schools and offices. Manual switch-controlled, continuous dimming systems were included in this designation...Automatic sweep controls were observed in many offices and retail buildings. Schools and other buildings with regular custodial staff often employed manual sweep control (in some cases this was true even when automatic sweep controls were installed).

Despite time clocks, OS, and sweep controls, significant amounts of lighting are left on at night and off hours. While this is often related to low level use such as product stocking of retail spaces, there is a strong trend toward leaving the emergency lighting circuits on around the clock.

Of the most common control types, occupancy sensors are the second most prevalent control technology employed in Oregon in 2007 behind on/off switches. Offices have the widest range of lighting control technologies employed, with 24% controlled by timeclock, 18% by EMCS, 21% by occupancy controls and 18% by control dimmer or daylighting. In many cases, multiple control types are used in the same building.

	Total	**Dry Goods Retail**	**Grocery**	**Office**	**Warehouse**	**School**
Control Timeclock (On/Off)	14%	17%	16%	23%	0%	9%
Control EMCS	14%	28%	7%	16%	15%	9%
Control Occupancy Sensors	17%	8%	12%	21%	32%	42%
Control On/Off Switch	80%	69%	91%	70%	80%	81%
Control Dimmer/Daylighting	7%	3%	0%	16%	0%	1%
Control Other	2%	0%	0%	6%	0%	7%

Figure 33. Lighting Control Types Employed in Oregon, Existing Buildings, 2007 (percentage of buildings)

Figure 33 and Figure 34 show the Market Actor Survey responses regarding controls in retrofit and new construction projects respectively. Note that the values in the table are percentage of *floor space,* rather than percentage of *buildings*, therefore the numbers are lower than the numbers in prior tables.

Occupancy sensors are by far the most common control type in both retrofit and new construction. In general, the use of controls in new construction projects appears to be very similar to the use of controls in retrofit projects, despite the difficulty of installing controls in retrofit applications if no wiring infrastructure is present. The only conspicuous difference between the two tables is that daylight harvesting controls are used in 11% of floor area in new construction, but only 4% in retrofits. This may be because newer buildings are more likely to have been designed for daylighting, i.e. to have more windows and/or skylights, whereas older buildings may be poorly daylit, and also because the lighting circuiting in older buildings may not be suitable, i.e. it may not run parallel to the windows. National data on daylight harvesting controls is not available, for comparison.

Building Type	**Multi-level manual switches ("bi-level")**	**Manual dimming controls**	**Occupancy sensors**	**Timeclock control**	**Daylight harvesting**	**Number of responses**
Offices	16%	7%	44%	7%	3%	39
Schools (K-12)	20%	9%	48%	6%	7%	19
Warehouses	11%	1%	53%	8%	3%	39
Grocery stores	13%	12%	27%	5%	5%	6
Assembly	0%	7%	47%	7%	0%	3
College/university	14%	6%	26%	10%	4%	5
Health services	50%	0%	50%	0%	0%	1
Hospital	20%	10%	50%	10%	10%	1
Multifamily residential	8%	6%	16%	24%	0%	5
Industrial	16%	1%	39%	8%	1%	19
Institutional	50%	10%	20%	10%	10%	1
Lodging	0%	20%	10%	10%	0%	1
Restaurant/bar	25%	28%	8%	18%	0%	4
Retail	20%	30%	47%	0%	0%	6
Weighted average	21%	9%	58%	11%	4%	

Source: Market Actor Survey

Figure 34. Lighting Controls Used in Retrofit Projects, 2009 (percentage of floor space)

Building Type	Multi-level manual switches ("bi-level")	Manual dimming controls	Occupancy sensors	Timeclock control	Daylight harvesting	Number of responses
Offices	14%	10%	54%	13%	10%	16
Schools (K-12)	13%	5%	58%	17%	28%	6
Warehouses	16%	4%	43%	10%	1%	11
Grocery stores	50%	0%	37%	7%	0%	3
Assembly	0%	0%	80%	20%	0%	1
College/university	8%	18%	58%	13%	38%	4
Health services	60%	10%	20%	10%	0%	1
Hospital	70%	10%	10%	10%	0%	2
Multifamily residential	15%	30%	30%	5%	20%	2
Industrial	13%	0%	59%	13%	0%	8
Institutional						0
Lodging	0%	50%	30%	0%	20%	1
Restaurant/bar	5%	55%	5%	5%	20%	2
Retail	10%	20%	30%	20%	20%	1
Weighted average	18%	10%	47%	12%	11%	

Source: Market Actor Survey

Figure 35. Lighting Controls Used in New Construction Projects, 2009

5.6 Market Actor Practices

5.6.1 Professional Practice

This section summarizes the analysis of the Market Actor Survey conducted in August and September of 2009.

In the following graphs, the questions and responses are shown in the order in which they were presented to the people taking the surveys. Rather than ranking the responses in order of how frequently they were chosen, we have retained the original order of presentation to preserve the internal logic to the question

Due to the limited size of the sample we have not tried to break out the responses by commercial vs. industrial (i.e. to provide separate conclusions for these two Energy Trust program areas). However, note that approximately 60% of respondents conduct industrial lighting projects in addition to commercial projects, so the majority of their professional practices are likely to be very similar in these two building types.

To provide an understanding of the type of work the market actors engage in, the survey asked respondents to indicate the type of services they provided. As described in the survey sample section above (section 4.1.2), we already had basic data on the respondents including: whether they were a Trade Ally (which included contractors and distributors; 59 respondents) or another market actor and whether they were a designer (which included lighting designers, electrical engineers, and architects; 16 respondents).

As can be seen in Figure 36, there are few respondents who only focus on one service/activity. Instead the majority of respondents are involved in multiple service areas. Most importantly, a large number of respondents (including many distributor and contractors) are involved in specifying or advising on the layout of lighting equipment (60% of respondents selected this as one of their service offerings, despite only 20% of the sample being lighting specifiers). This is further discussed with Figure 36, below.

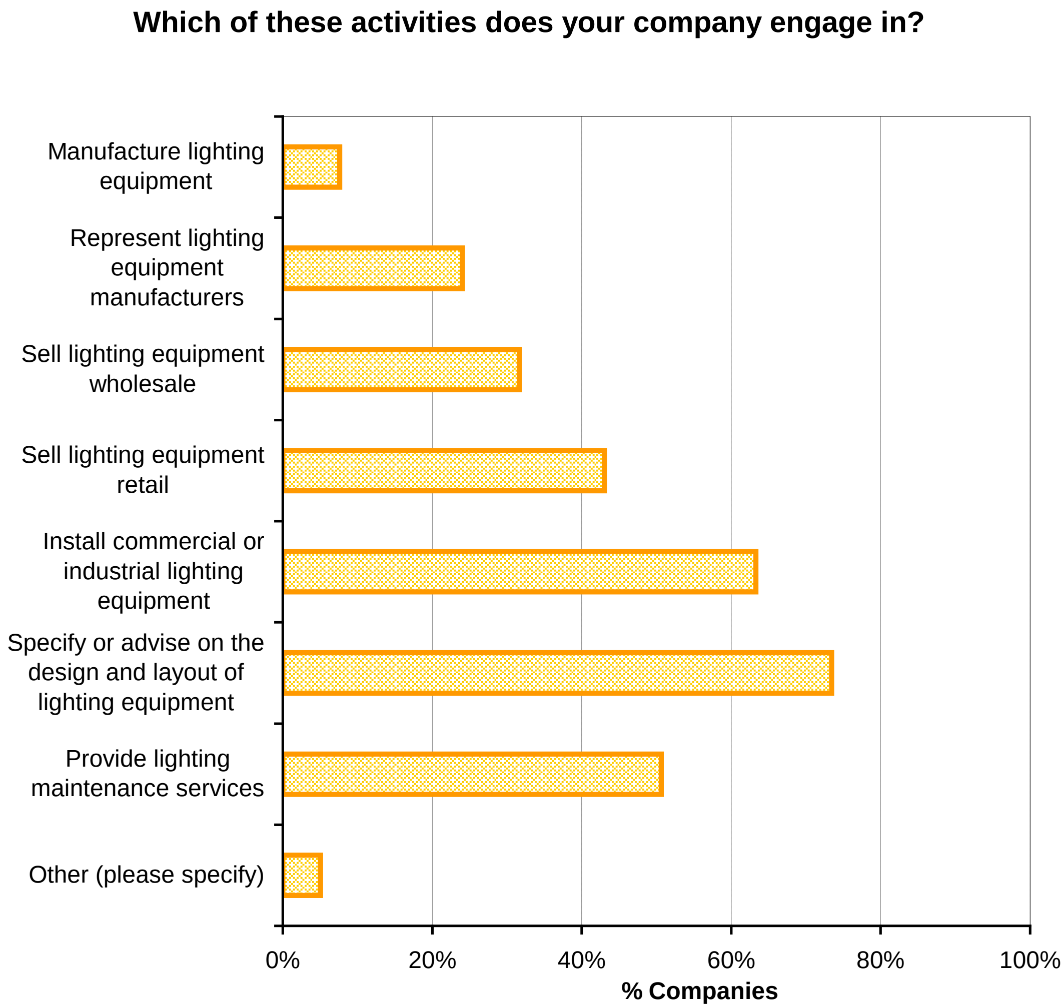


Figure 36. Company Activities

Figure 37 shows that, despite the high proportion of respondents who advise clients on the design and layout of equipment, few of them have undergone formal training in lighting engineering or design, despite the ready availability of courses through both the IESNA and the NCQLP. The responses were also clustered, i.e. eight companies had someone who had more than two formal lighting qualifications (for instance an IES course and LC certification), but most companies (62 out of 83) had nobody with any formal lighting qualification. Note that the four respondents who were registered architects were all from architecture firms.

By far the most common source of training in lighting is courses offered by manufacturers. Manufacturer courses typically provide professional development credits, and combine "objective" lighting training (for instance calculations, lighting quality recommendations) with training that is specific to the manufacturer's own products (for instance the performance and features of new products, or installation training).

Manufacturer trainings are typically conducted either at the client's office over lunch time, or as a full-day training at the manufacturer's facility.

People who checked "other" had gone through training in lighting audits and available incentives, rather than technical training. Within the 'other' category the following is some of the responses of certification/training not listed in the selection below: 1) had a Bachelors in Architecture; 2) 'Certified Green Lights Surveyor'; 3) was an instructor of lighting courses (some of which were listed as a choice); 4) was a member of IES; 5) had a MFA in Lighting Design.

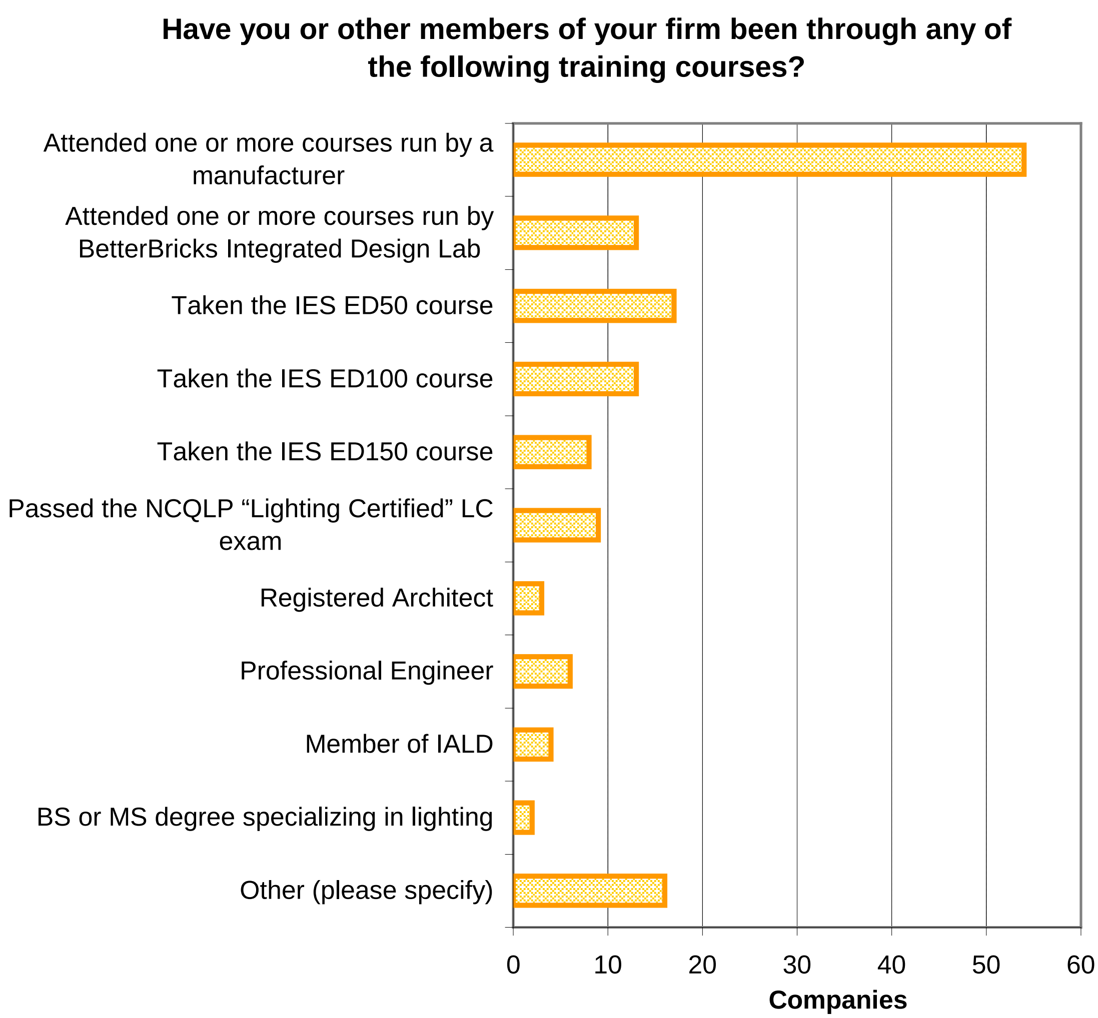


Figure 37. Training Courses Attended

Figure 37 corroborates the importance of manufacturers in lighting training and education. Manufacturers were the most common source of updates on new lighting technologies and design trends. Most respondents obtain updates from a variety of sources, with more than 50% of people consulting trade magazines, maintaining membership in a professional organization, and reading trade magazines. Slightly less than 20% of people said that they used BetterBricks for lighting updates.

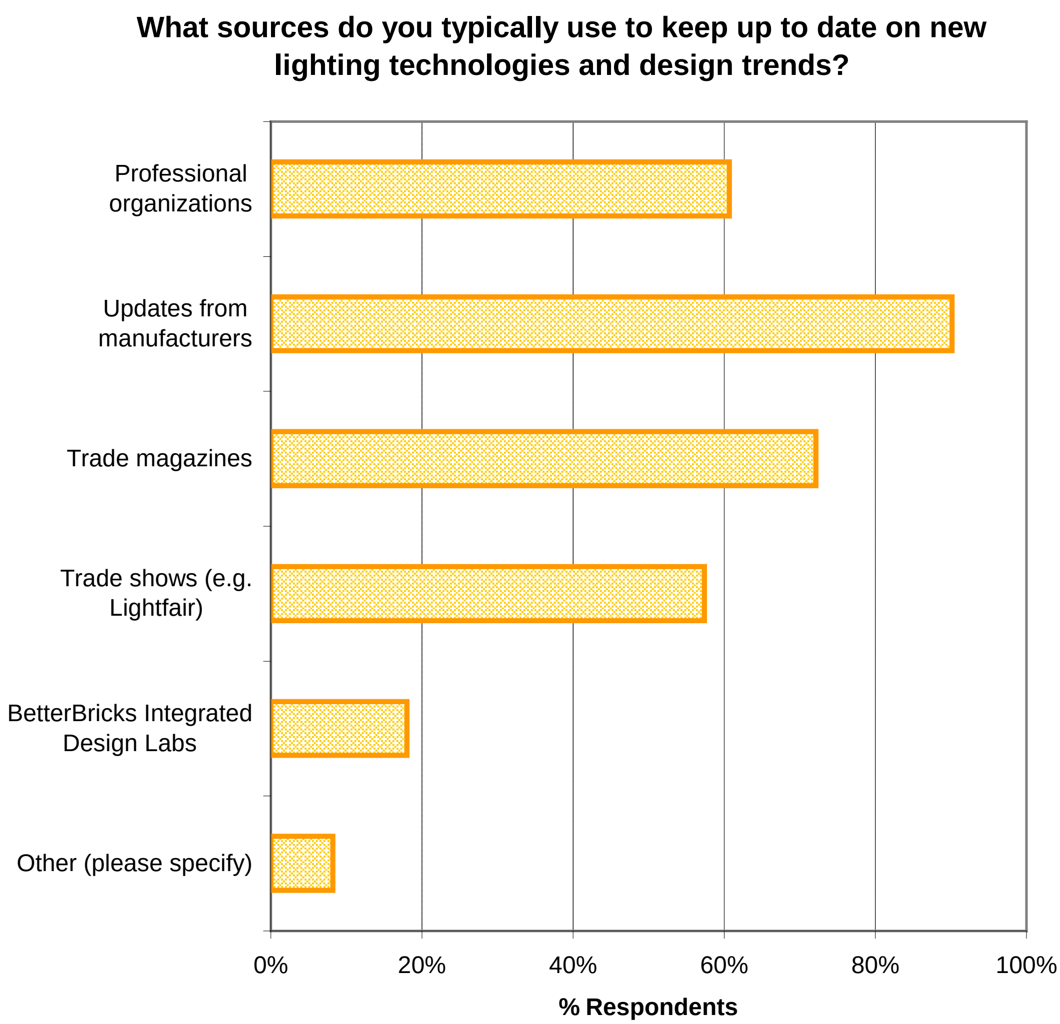


Figure 38. Sources of Lighting Technology and Specification Trends

As a check on the types of people responding to the survey, we asked what percentage of their work was commercial and industrial lighting in Oregon. The modal response was 100%--over 30% of respondents did nothing except commercial and industrial lighting, while the remaining 70% were somewhat evenly distributed, from lighting specialists who did a small amount of non-lighting work, through to a few people for whom lighting less than 30% of their work. But in general, as expected, the survey respondents spend most of their professional time on lighting projects.

We asked whether people were familiar with the term "High Performance T8". Following advice from the trade ally group we did not ask a detailed questions about the technical definition of HP T8, we just asked whether they knew what it meant, and whether they discussed it with clients. As shown in Figure 39, respondents overwhelmingly knew what the term meant and discussed it with their clients. This suggests that at least the *idea* of HP T8 is widespread in Oregon.

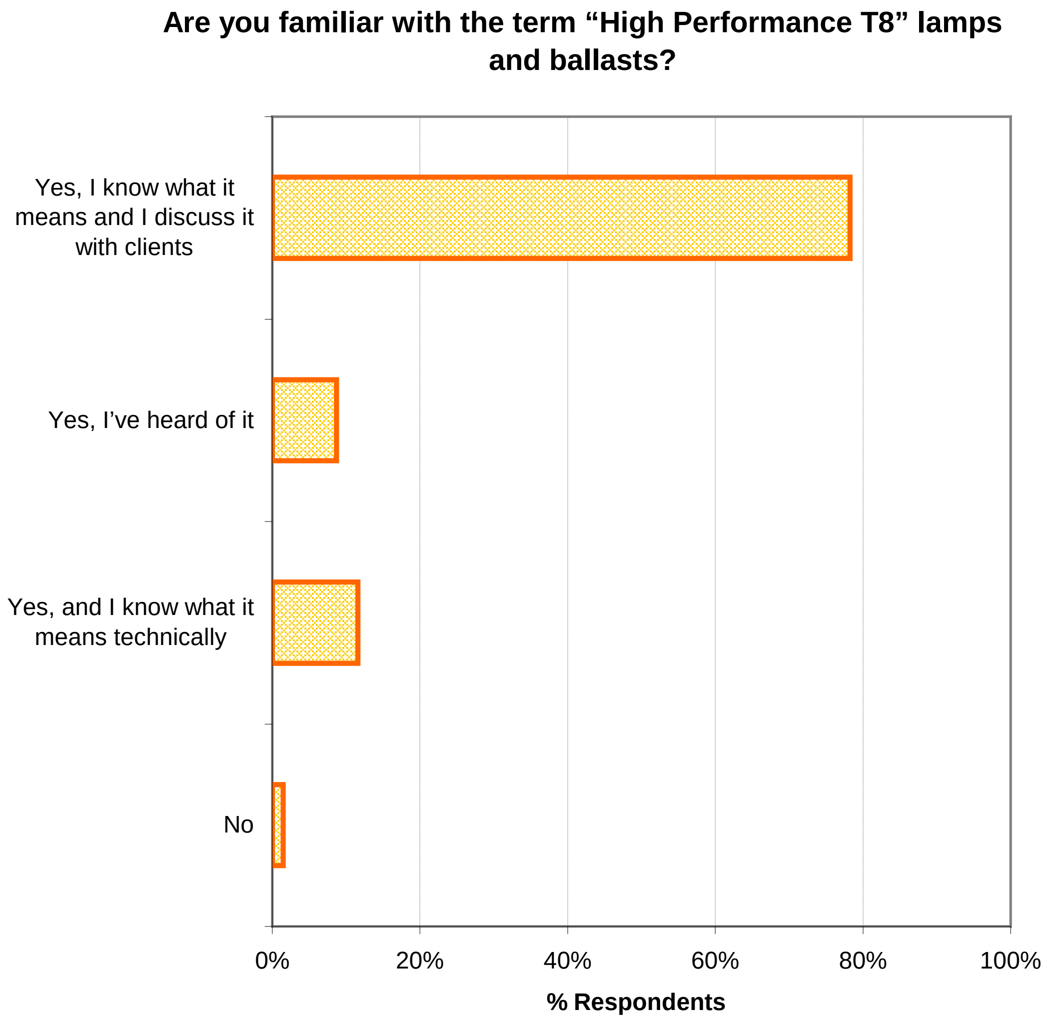


Figure 39. Familiarity with the term 'High-Performance T8' Lamps and Ballasts,

We followed up by asking where they had obtained information about HP T8, and again there was an overwhelming response—Lamp and ballast manufacturers, and Energy Trust (including the Trade Ally Network) were the primary sources of information, as shown in Figure 40.

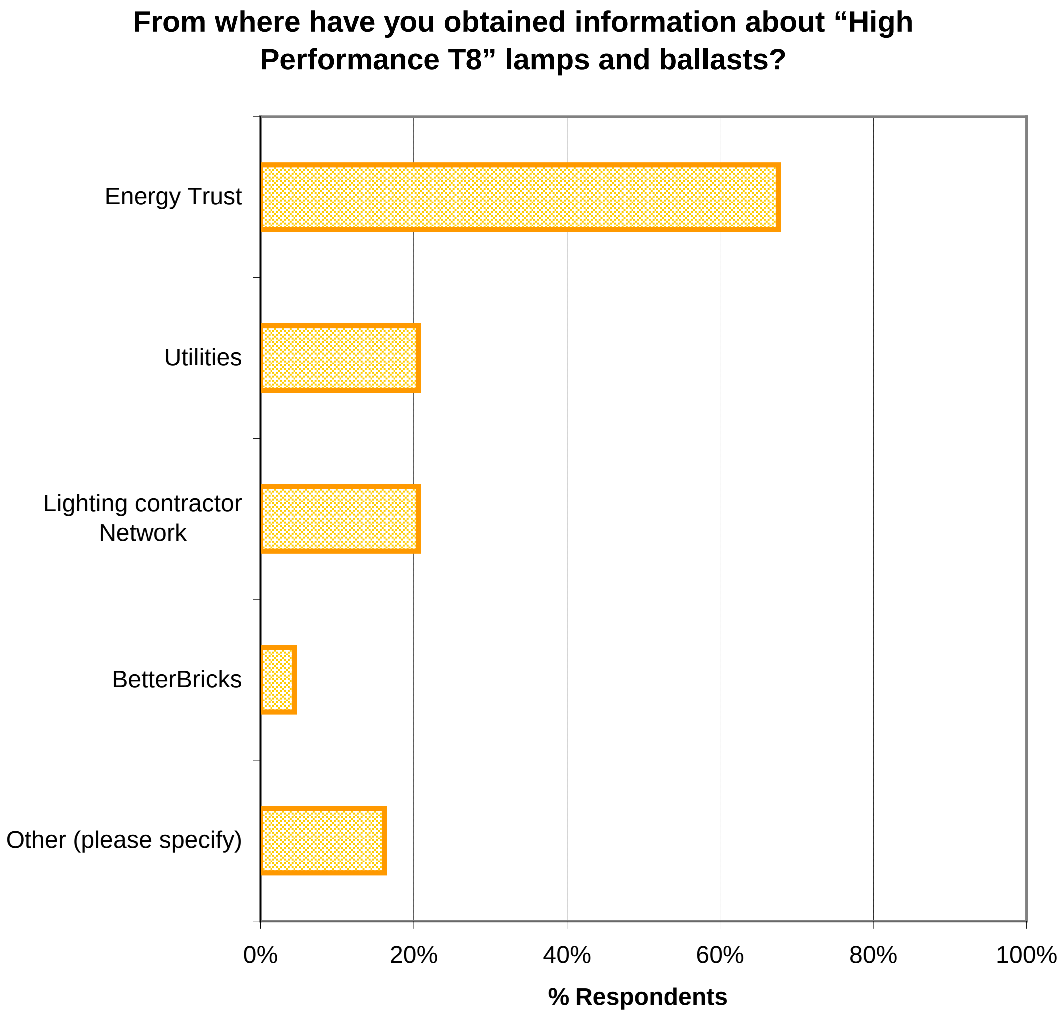


Figure 40. Resources for Obtaining Information on 'High Performance T8' Lamps and Ballasts

Based on information from the Trade Ally Network we knew that trade allies were commonly involved in the specification, layout and design of lighting, so we wanted to know more about the technical basis on which they provide advice. Figure 41 shows that respondents mostly rely on their customer's specifications or their own previous experience to determine illuminance levels and power densities, and that they less frequently rely on code or IESNA recommendations. This may suggest that respondents are already sufficiently familiar with code and with IESNA guidance that they do not need to refer to it very often, but it may also suggest that many of the respondents do not always check the lighting design against the requirements of code or IESNA.

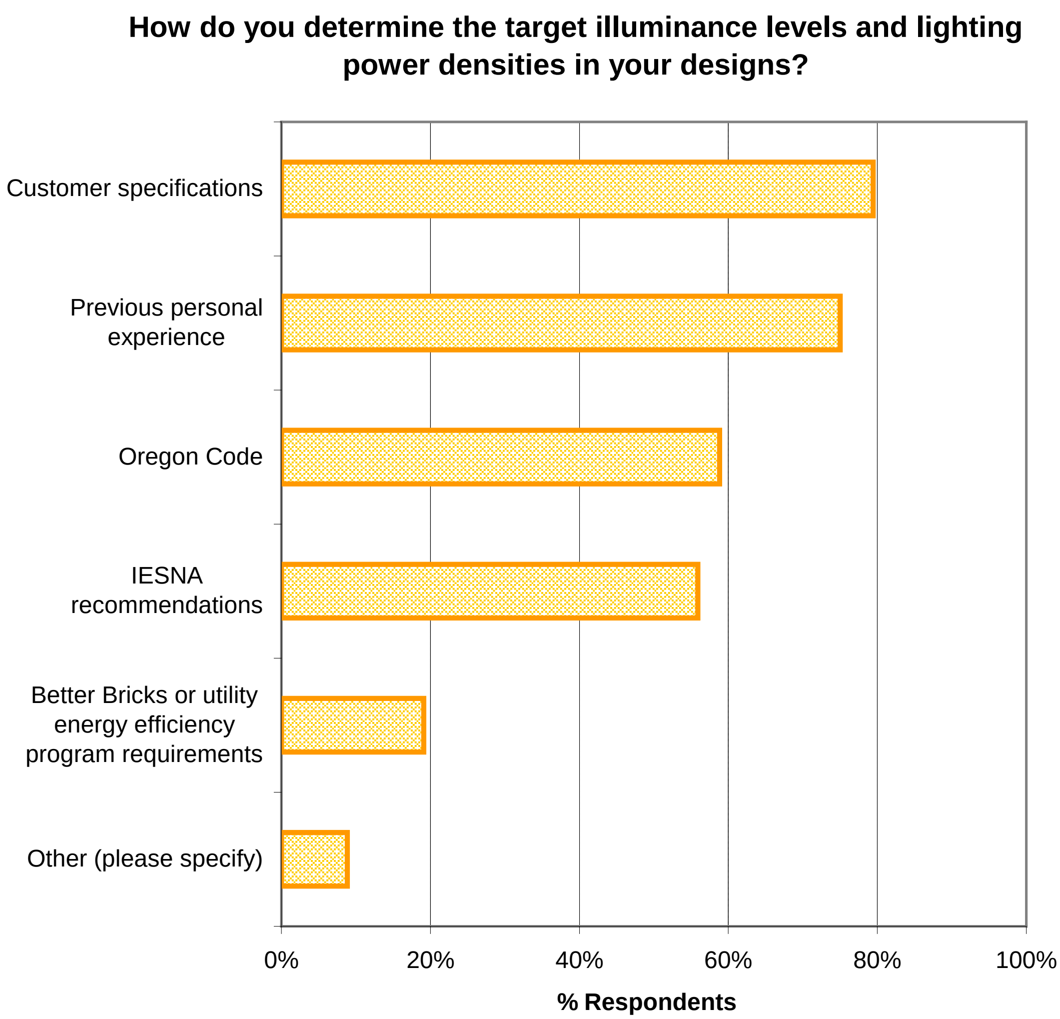


Figure 41. Methods for Determining Target Illuminance Levels and LPDs

We asked whether respondents commonly work on retrofit projects or on new construction projects, and found that most individuals work almost exclusively on retrofit and equipment replacement projects. 90% of respondents work on renovation and equipment replacement for more than 10% of their project work. By contrast, only around 40% of respondents work on new construction projects for more than 10% of their project work. By contrast, the NEEA 2000 study found that their 28 respondents conducted 50% of their work on new construction projects, and 50% on retrofit (either major renovation and remodeling, retrofit of operable equipment, and retrofit of failed equipment)[1]. Note that the current economic downturn has severely reduced the number of new construction projects being undertaken.

[1] NEEA 2000 Xenergy Northwest Lighting Market Assessment. Page 5-5. Table 5-4.

The most common building types respondents work on (see Figure 42 and Figure 43) are offices, warehouses, and industrial buildings. Comparing this with the statewide square footage values in Figure 12 shows that two building types—retail and lodging--seem to be underrepresented. This may be because the owners of those buildings (which tend to be corporate chains) retain their own specialist lighting design and contracting teams rather than hiring local contractors. Energy Trust's program data shows that the retail sector is represented in proportion to its load, so it may simply be that contractors who specialize in retail are under-represented in our survey sample.

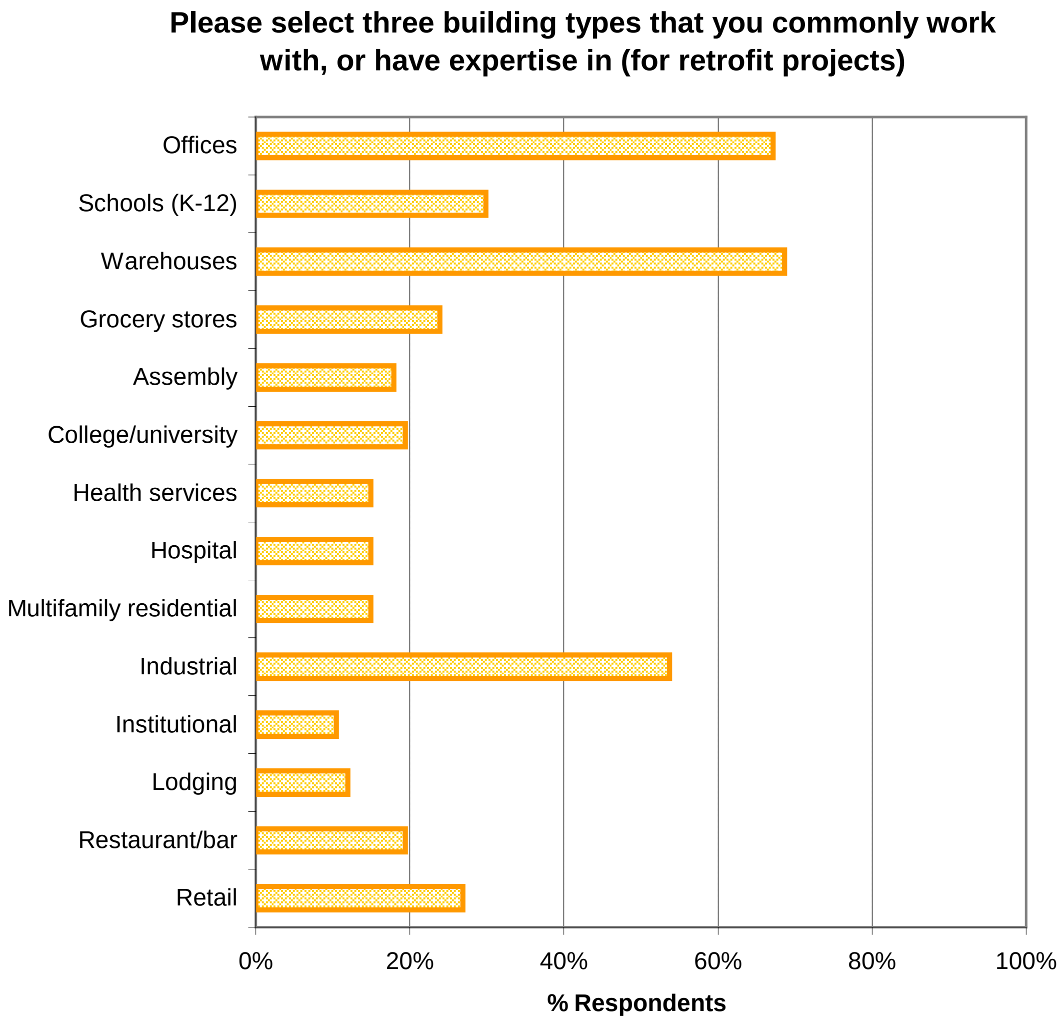


Figure 42. Three Most Common Building Types for Retrofit Projects

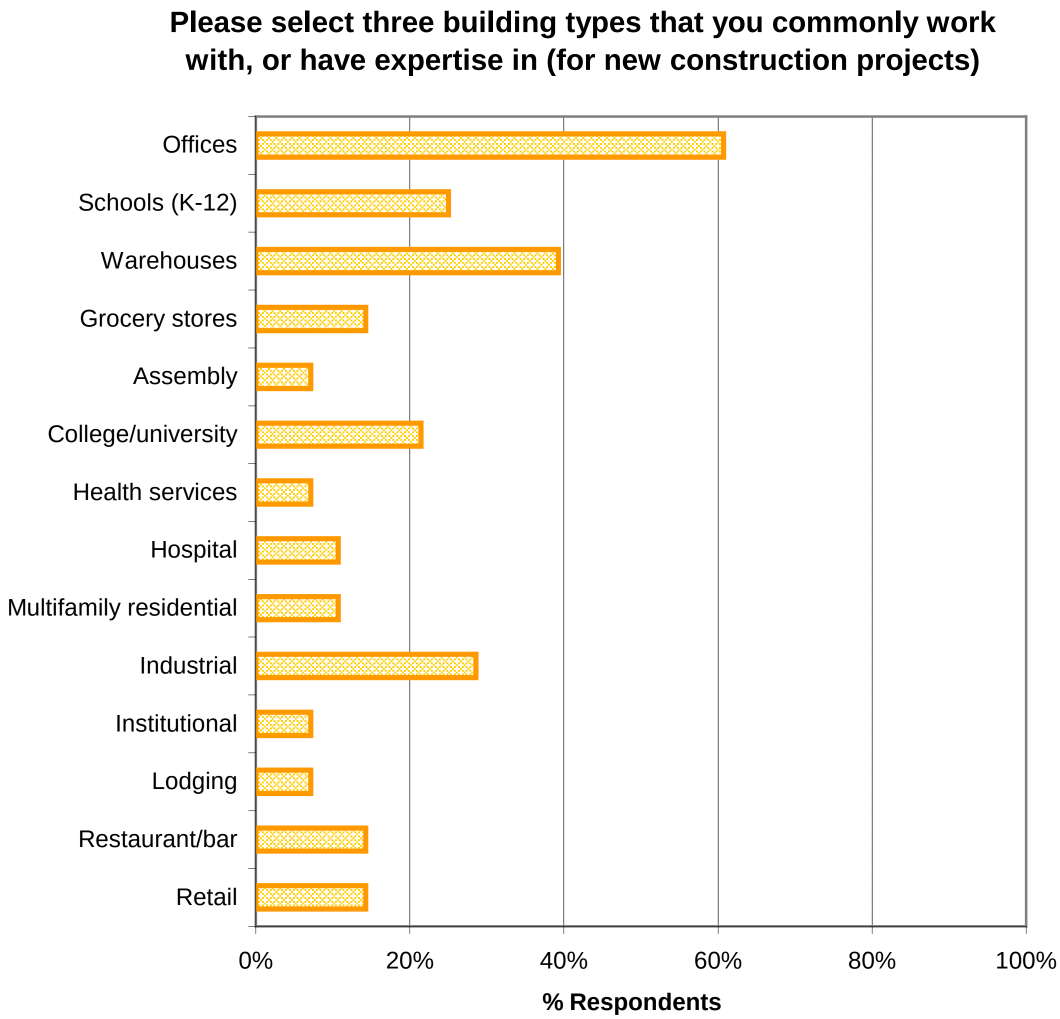


Figure 43. Three Most Common Building Types for New Construction Projects

5.6.2 Incentives and Performance Relative to Code

To find out how proactive the market actors are, in regard to encouraging lighting that exceeds code, we asked them on what percentage of their projects they discuss with their client the possibility of going beyond the requirements of code (Figure 44). Just over 20% said that they *always* have this discussion, which suggests that are extremely proactive. The remaining responses show a wide range, with a small number of respondents *never* discussing the idea of exceeding code. Given that the respondents are lighting specialists who spend most of their professional time on lighting, they probably have the knowledge and experience to confidently discuss options for going beyond code, and it seems that they are taking this opportunity, on average, a little more than half the time (average was 56% of the time).

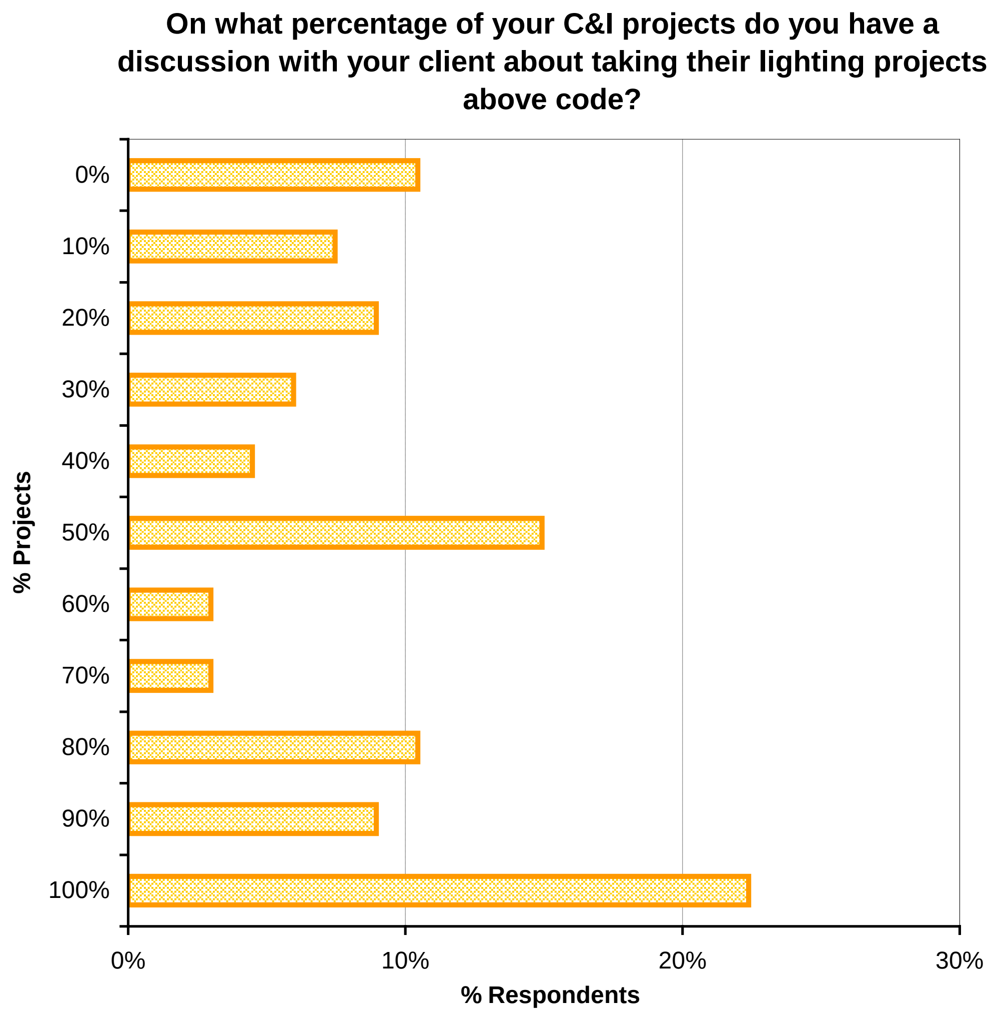


Figure 44. Frequency of Talking to Clients about Exceeding Code

Figure 45 shows that the majority of projects (69%) actually end up being "better than code". Of course, in many cases these projects may only be *slightly* better than code, but this is still an encouraging number.

However, it is noteworthy that projects appear to exceed code *more often* than the respondents discuss going beyond code with clients (see previous figure). If respondents were being highly proactive and struggling to persuade skeptical clients, it could be expected that the number of projects exceeding code would be less than the number of projects on which these discussions were instigated. This suggests that if trade allies and other market actors started these discussions more often, they would likely meet with success. Of course there may, in many cases, be a split incentive such that it's not in the interest of market actors (distributors and contractors) to persuade their clients to use fewer light fixtures; this may be especially true in new construction.

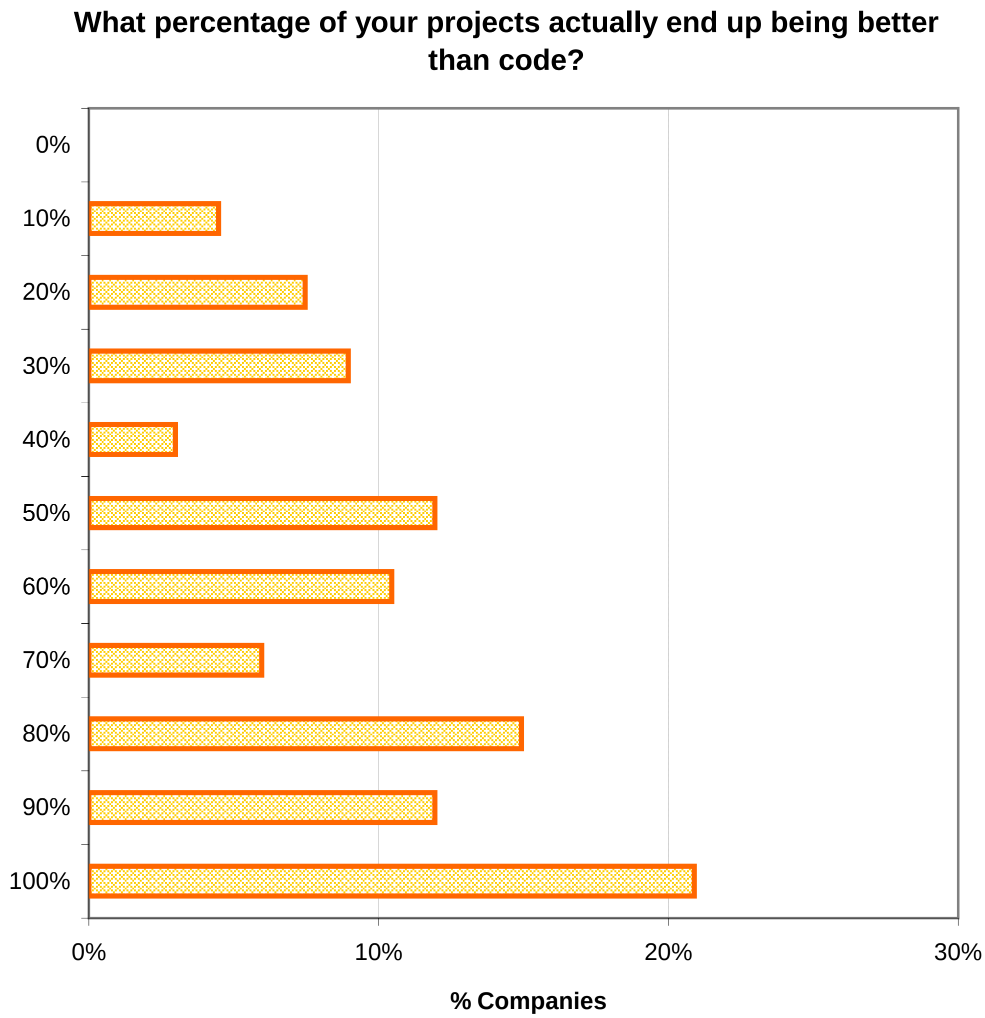


Figure 45. Frequency of Projects that Ultimately Exceed the Code

The next figure, Figure 46, shows the main reasons respondents chose to exceed the code. It shows that financial incentives are a major factor in the decision, which suggests that Energy Trust should continue to focus on incentives to achieve market change.

Reduced life-cycle cost and maintenance cost of the equipment is also a major factor, which suggests that high efficiency lighting products are seen as a long-term benefit rather than a liability.

Improved quality of the visual environment is also a major factor, which suggests that the improved light quality typically offered by 800 series T8 over less-efficient alternatives is a major driver for specifiers or facilities managers.

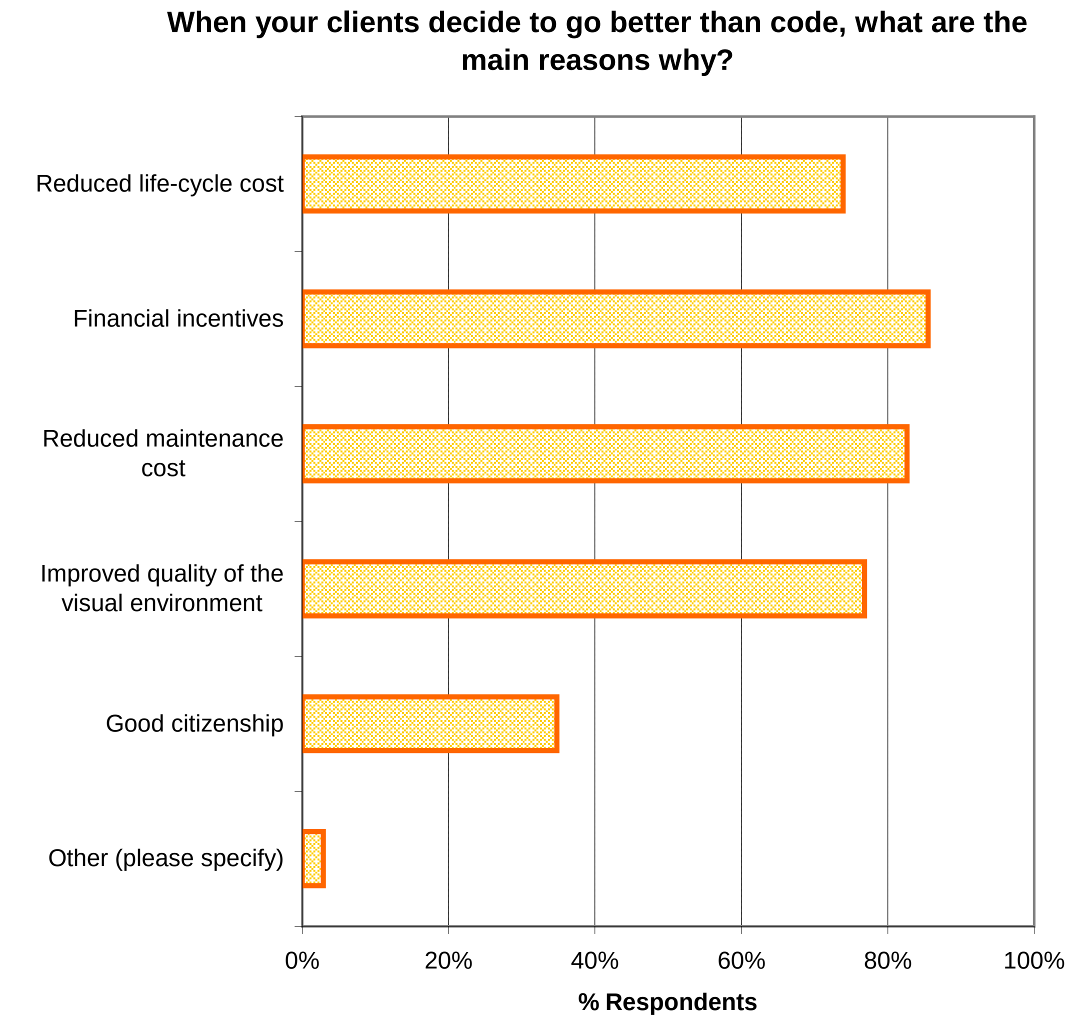


Figure 46. Motivations for Exceeding the Code

Figure 47 shows reasons why clients did *not* exceed Code, i.e., this is the opposite of the previous question. This question did not have as many dominant reasons. Instead, very clearly, the majority of respondents (~91%) indicated in Figure 47 above that 'added capital cost' was the primary limiting factor to exceeding the code on projects. The next reason, which by contrast only 33% of respondents chose was 'uncertainty of performance of equipment.'. If this uncertainty refers to lighting controls, then this suggests that many respondents are assuming that to exceed code they require additional equipment, rather than just reduced light levels or better use of existing equipment. Respondents who chose 'other' (~9%) most frequently indicated that this was either a lack of forward planning or a lack of education.

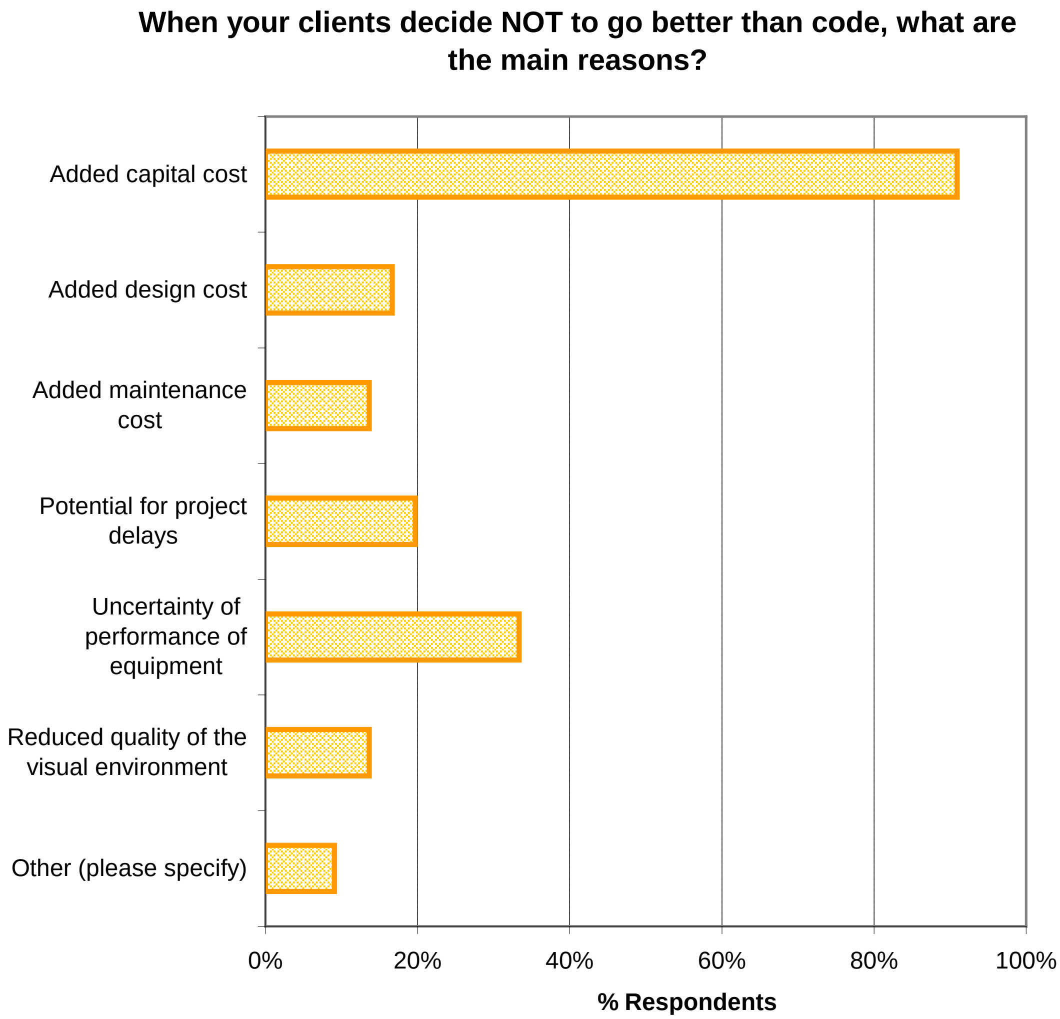


Figure 47. Motivations for Not Exceeding the Code

In a similar vein, we asked which issues can make or break a client's decision to use lighting controls on a project (Figure 48). The answers are perhaps most notable because the respondents did *not* overwhelmingly say "potential for failures" which is frequently given in the lighting profession magazines and discussions as a reason why controls are not more widely used. The issue of user decommissioning of daylighting controls was seen as less problematic than user decommissioning of occupancy controls, though this must be seen in the context of occupancy controls being much more common than daylighting controls.

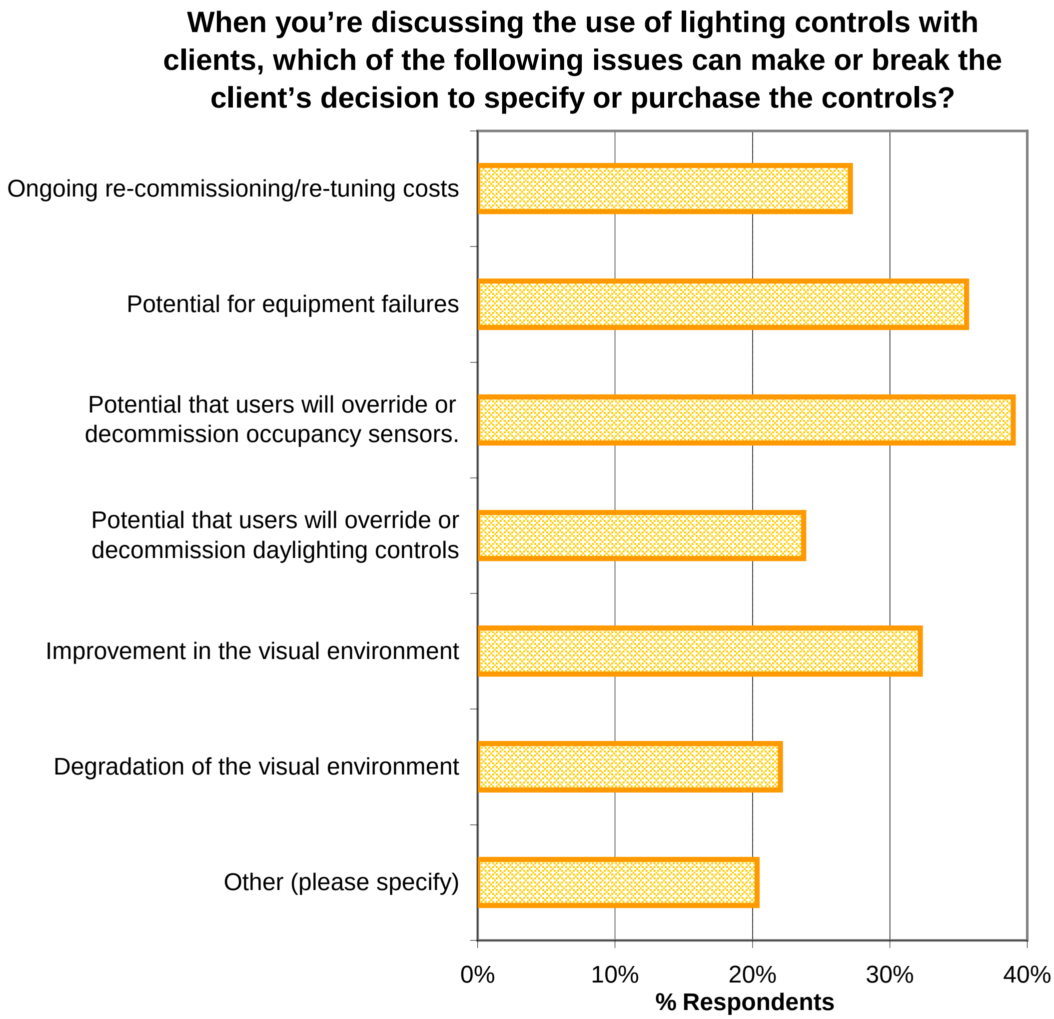


Figure 48. Key Issues for Controls Specifications

5.6.3 Energy Trust Influence

Over 90% of respondents had worked with the Energy Trust. Less than 10% of respondents have not. We asked them a variety of questions intended to find out how much influence Energy Trust has had on their own practices, and on the market as a whole.

Figure 49 shows that 23% of respondents who said they had worked with Energy Trust would *always* have discussed exceeding the code, even without Energy Trust incentives, but 70% said only that they *may* have done so in many, or a few cases. These answers, again, suggest a wide mix of dispositions and practices among the respondents—from a highly proactive stance on energy efficiency to a mostly passive approach. The responses also suggest that in many cases Energy Trust's incentives are prompting Trade Allies to have conversations they might not otherwise have.

It is likely that the 23% who would have had the discussion are the same group that discusses exceeding the code as standard practice (100% of their projects, see Figure 45).

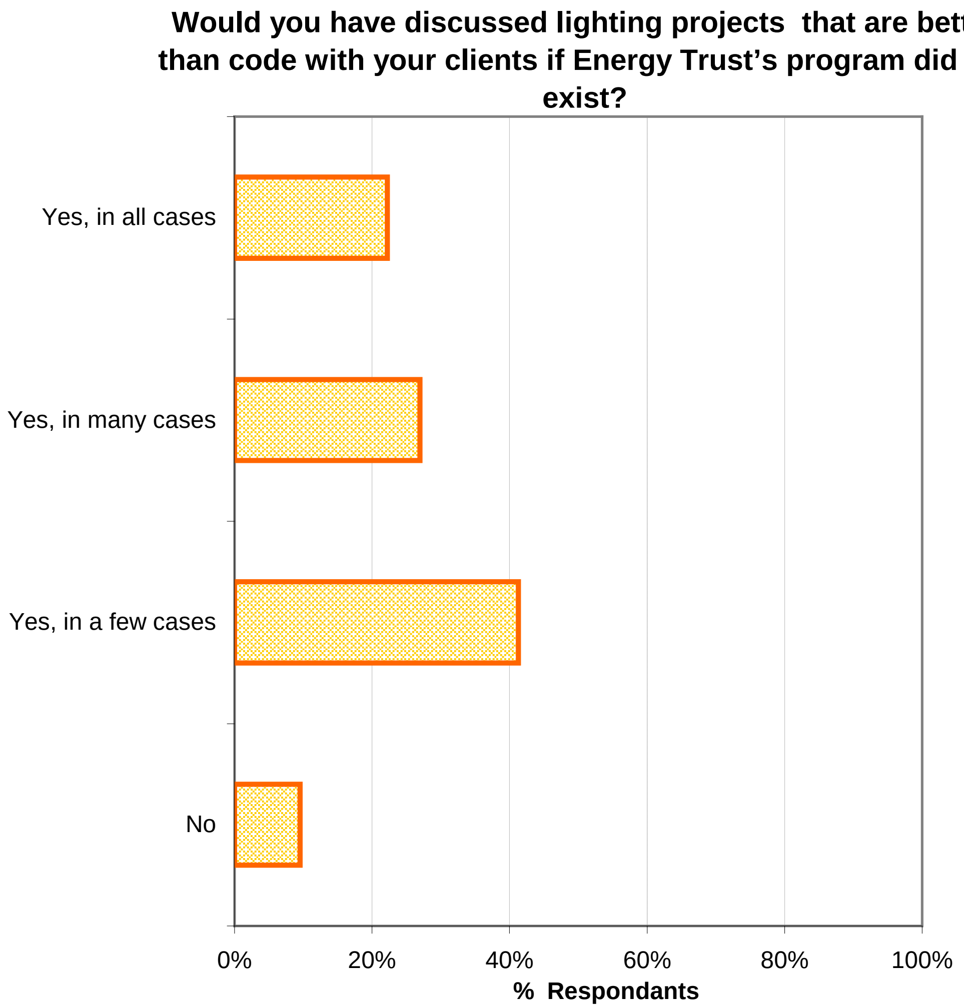


Figure 49. Likelihood of Discussing Going Above Code in the Absence of Incentives

Figure 50 shows what is usually called "freeridership" on High Performance T8 lamp/ballast incentives, i.e., how many projects would have gone ahead even if Energy Trust's incentives had not been available. It shows, on average, that 36% of projects would have used HP T8 lamps regardless of available incentives. This answer is typical of answers to "self-reported" freeridership questions, i.e. it is not notably high or notably low; a certain amount of freeridership is inevitable in any program that provides incentives, especially if the attempt is to transform the entire market.

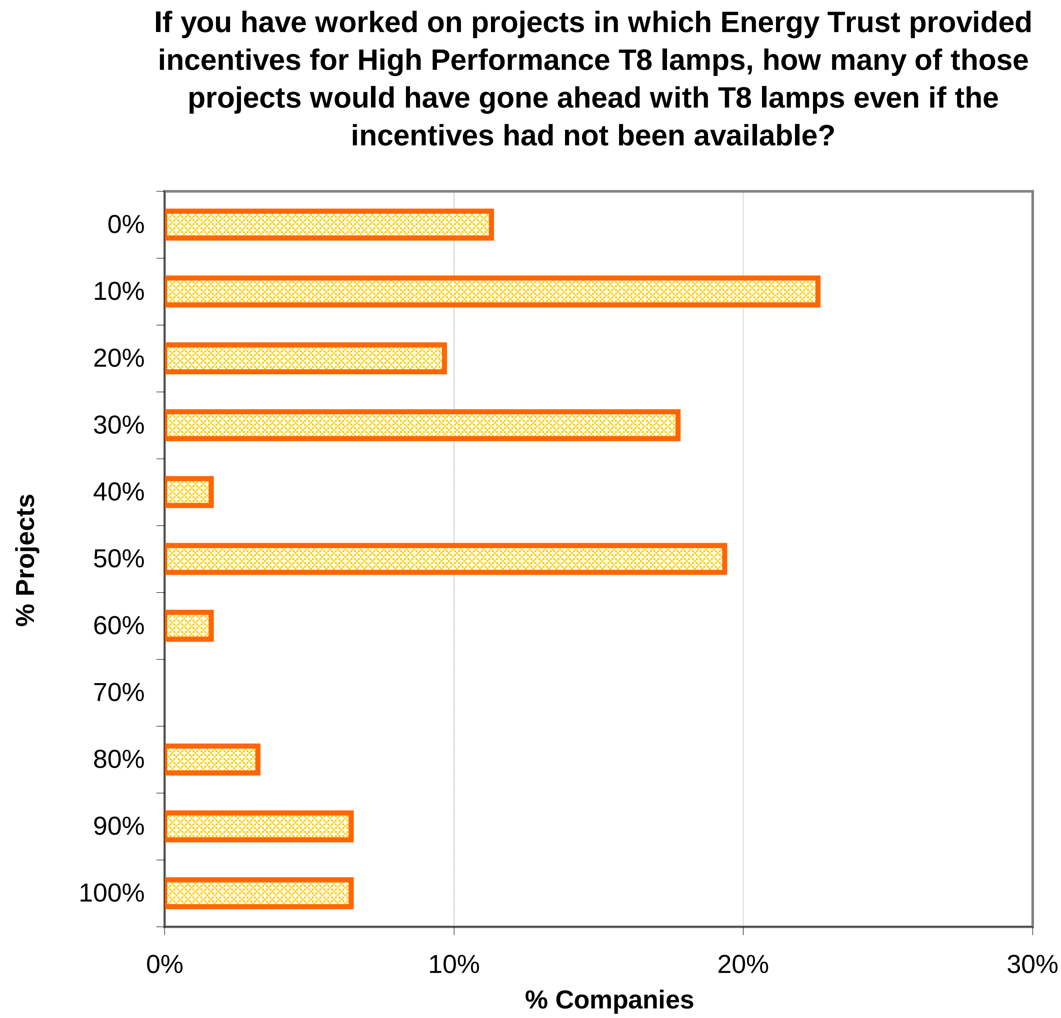


Figure 50. Freeridership on High Performance T8 Incentives

Figure 51 shows the answers to the direct question "how much influence do you consider Energy Trust to have had in the recent adoption of High Performance T8 lamps and ballasts in Oregon?" The modal response, with 55% of answers, is that Energy Trust was a "major influence"; less than 20% of people considered Energy Trust to have had only a "minor influence", and almost 30% of respondents believed that energy Trust was "*the most important*" influence in the adoption of high performance T8. Very few respondents (2%) thought Energy Trust had no influence at all. Note that this "influence" question is separate from the question about free-ridership—the responses in Figure 51 should not be modified by the freeridership percentages shown above.

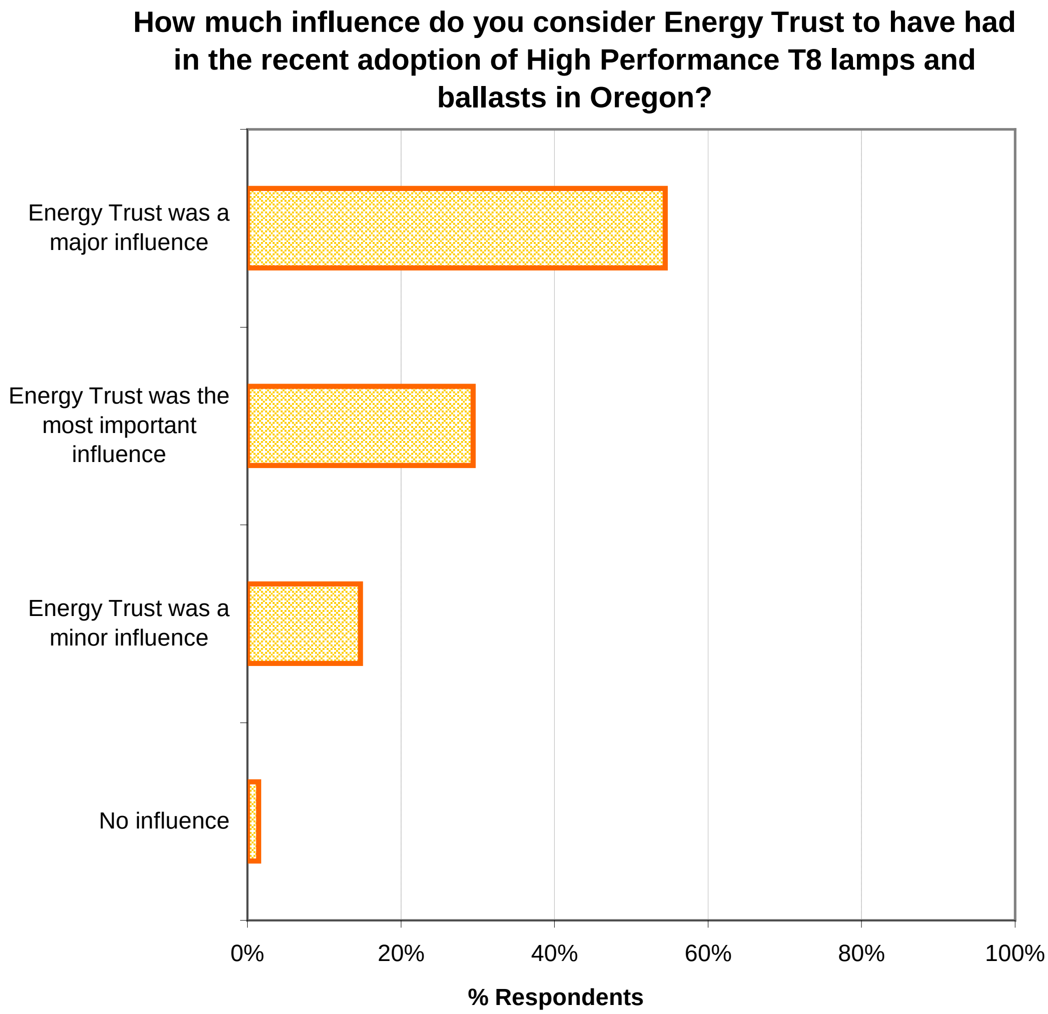


Figure 51. Energy Trust Influence in Market Adoption of T8 Lamps and Ballasts

The same as for High Performance T8, we asked about freeridership on *controls* projects. Figure 52 shows that freeridership was generally believed to be slightly lower than for high performance T8, on average only 30% as opposed to 36%. This is still within the typical range of free-ridership values for incentive programs. The lower freeridership for controls may be because more effort on the part of the client is required to specify and install controls, i.e. the decision to use controls is less likely to be made without the help of the Trade Allies and therefore without program incentives.

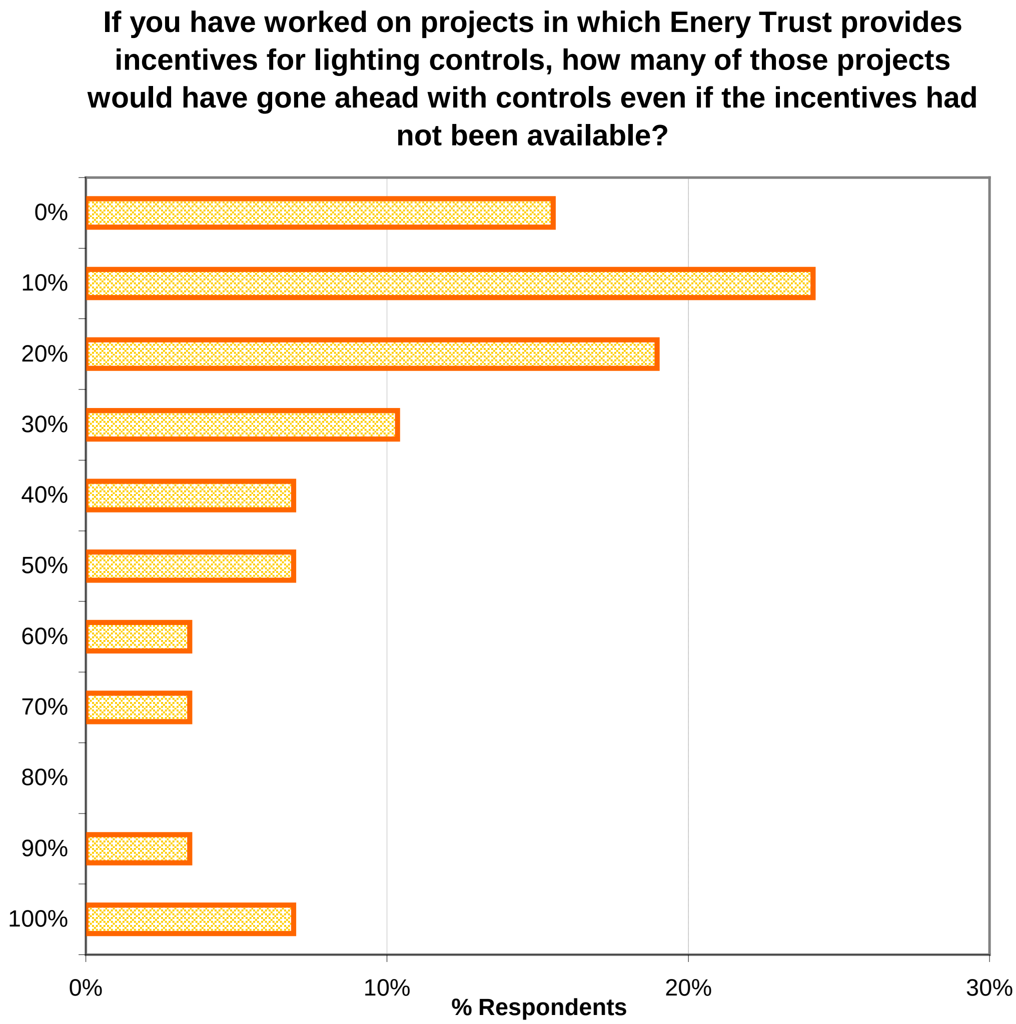


Figure 52. Freeridership on Lighting Controls Incentives

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Methodological Issues

1. **Limitations of Available Data.** This study uses multiple types of data to arrive at conclusions about the lighting market. The different types of data have strengths and weaknesses. In particular we have been surprised by the high degree of variation that seems to be inherent in field study data--even between studies that use the same method several years apart. These variations seem to be caused in many cases by the inclusion or exclusion of a few large and influential buildings from a dataset. In many cases a more robust conclusion can be obtained from field data when it is weighted by the *number* of sites rather than the *square footage* of sites to avoid this effect.

- By combining data of different types (interview data, site survey data, data from models) a more complete picture emerges, in which individual variations are less pronounced.

6.2 Changes to the Lighting Market

These conclusions pertain to the Oregon market. We have not attempted to compare changes to the Oregon market with national changes over the same period, because national data from the federal Commercial Buildings Energy Consumption Survey (CBECS) will not be available until early 2010 at the earliest[1]. The only other state with detailed lighting data by building type is California, which would not provide a baseline comparison due to its aggressive energy codes and programs.

2. **Changes in Prevalence of Lamp Types.** T12 and HID lamps have declined sharply in existing commercial buildings, while T8 and CFL have increased. Note that HID has declined in warehouse and industrial applications but observational evidence shows that at the time of writing ceramic metal halide is increasing dramatically in retail.

   These findings are to be expected, but more surprising is that incandescent lamps present a mixed picture—there appears to have been a slight increase in the use of incandescent lamps in some applications (for instance grocery stores) over the last decade, although their use has declined overall. Note that within the category of "incandescent lamps" there are more efficient technologies than standard A or PAR lamps, such as mains voltage halogen and low voltage halogen, and that the market for these (especially in retail) has grown significantly over the past few years. These more efficient lamps may be responsible for much of the apparent increase.

[1] We contacted CBECS to ask about the availability of new data, which had previously been scheduled for the Fall of 2009. They did not give an estimate but said that they had encountered significant difficulties with the data, so we do not expect a revised data set to be available this year.

- RECOMMENDATION: **Consider New Incentives for Ceramic Metal Halide in Retail Retrofits**. The rapid adoption of ceramic metal halide in new-construction retail suggests that the price of these lamps has dropped, and they may be well positioned for inclusion in retrofit programs, as a replacement for incandescent. According to Energy Trust's program data in Appendix E, only 9% of program savings in the retail sector have come from replacement of incandescent lamps in the past few years. We recommend that Energy Trust should convene a group of HID manufacturers and specialist distributors to reappraise which metal halide lamp types Energy Trust could incentivize, and in which applications. Because very few of the Trade Allies do a lot of work in retail, Energy Trust may choose to conduct special outreach to those contractors, or directly to major retailers. The retail sector uses more lighting energy than the office sector, and has higher lighting use intensities, and has not recently been served by specific initiatives from Energy Trust or NEEA.

3. **Federal Requirement for More Efficient Linear Fluorescent Lamps.** Despite the virtual elimination of T12 lamps from new construction, 17% of all lighting in existing buildings is still provided by T12 lamps, according to the NEEA Commercial Buildings Survey. Federal rules will prohibit the sale of magnetic T12 ballasts starting in June 2010, and the sale of most T12 lamps in July 2012, which means that in advance of the 2010 deadline there is a huge opportunity for Energy Trust to help to optimize the new lighting that will replace the T12 lamps and ballasts. If existing T12s are simply replaced one-for-one with new T8s the potential exists for significant overlighting or underlighting of spaces, and missed savings.

    - RECOMMENDATION: **Plan to Maximize Savings from Mandatory T12 Retrofits.** Energy Trust should make a special effort to identify buildings that still have T12 lamps and provide building owners with information about the forthcoming federal rule and their options for improved lighting, including the potential that a simple one-for-one changeout of T12 for HP T8 will lead to spaces being overlit. Note that according to data from Energy Trust's program, the vast majority of current projects involve one-for-one changeouts (see Figure 53). Energy Trust should be active in encouraging trade allies to choose ballasts based on ballast factor, to reduce energy use and light levels in spaces that would otherwise be overlit.

      While preparing for the 2012 change, Energy Trust should also work with lamp manufacturers to identify any potential loopholes in the new Federal requirements that would allow less efficient fluorescent lamps to continue to be used in some applications, and work with the DOE and EPA to close those loopholes if they exist. Due to the complexity of the Federal requirements, HMG has not conducted an in-depth study of which lamp types may not be covered by the new requirements—we believe that only lamp manufacturers have sufficiently detailed knowledge of their products to identify these loopholes.

Replaced Type	T8 (HP)	T5	CFL	T8	HID	Total
% of installations that are one for one quantity	93%	67%	94%	95%	82%	91%

Figure 53. Percentage of Energy Trust's Retrofit Projects that are One-for-One Lamp Changeouts

4. **Federal Requirement for More Efficient Incandescent Reflector Lamps**. Incandescent lamps still make up 18% of lighting wattage in existing C&I buildings according to the NEEA Commercial Building Stock Assessment, and 10% of lighting wattage in new construction according to NEEA's Baseline study. Federal rules will require incandescent reflector lamps sold after July 2012 to meet higher efficacy requirements.

   The effect of this change cannot be known in advance, but the worst-case scenario is that existing incandescent lamps will be replaced with more efficient incandescent lamps, rather than with HID or LED lamps.

   In the absence of other information, incandescent lamp purchasers (such as grocery stores and retailers) may replace their existing lamps with lamps of the same wattage, which will result in overlighting and will fail to achieve energy savings.

   - RECOMMENDATION: **Plan to Maximize Savings from Incandescent Lamp Retrofits.** Energy Trust should work with retailers, contractors, distributors, production home builders and other incandescent lamp purchasers to ensure that they realize the savings available from more efficient incandescent lamps, rather than simply replacing lamps with new lamps of the same wattage.

     Energy Trust may wish to consider other scenarios for the 2012 change, such as the potential for retailers and others to "leapfrog" over high-efficiency HIR lamps and move directly to ceramic metal halide or LED. This would require those market actors to be well versed in the technical options available to them.

     While preparing for this change, Energy Trust should also work with lamp manufacturers to identify any potential loopholes in the new Federal requirements that would allow less efficient incandescent lamps to continue to be used in some applications, and work with the DOE and EPA to close those loopholes if they exist. Due to the complexity of the Federal requirements, HMG has not conducted an in-depth study of which lamp types may not be covered by the new requirements—we believe that only lamp manufacturers have sufficiently detailed knowledge of their products to identify these loopholes.

5. **T5 HO May Be Overused.** T5 lamps are approximately half as common as T8s in current C&I retrofit projects—24% and 53% of lamps, respectively. T5 has become dominant in warehouses and industrial facilities, displacing HID rapidly in the past few years. Warehouses are a suitable application for T5 because the small size of the lamps makes them effective at focusing light down to the floor from the top of a tall warehouse aisle, and reduces the cost of the fixtures. However, if high output T5 is used instead of regular T5 or HPT8, some of the performance benefit over HID is lost. Also, efficient direct replacement options now exist for HID lamps, which Energy Trust may want to consider.

   - RECOMMENDATION: **Reconsider Incentive Structure for T5 HO and Consider Promoting Other Lamp Types in Industrial Buildings and Warehouses.** High Output T5 is less efficient than regular T5. For background data on this, see Appendix E, Table 7, which shows that in Energy Trust programs, T5 HO lamps saved a smaller percentage of existing watts than regular T5, in equivalent commercial applications (note that industrial applications used no regular T5 so no comparison could be made). This may not be a totally accurate comparison, because, because the achieved light levels may not have been the same. However, a brief calculation of efficacies from a manufacturer's website[1] shows that for 4' T5, high output is 8% less efficient than regular T5.
   - Therefore we recommend that Energy Trust should review program information and Trade Ally materials to ensure the regular T5 or HP T8 is used wherever possible, unless in a specific project T5 HO would allow more energy to be saved because it would allow the use of more efficient fixtures or fewer lamps than regular T5.

Replacement/Replaced Combination	Regular T5	High Output T5
2-lamp T5 Fixture Replacing 2-lamp T12s	60%, N=14	43%, N=22
2-lamp T5 Replacing Incandescent	70%, N=3	44%, N=3
1-lamp T5 Replacing 1-lamp T12	87%, N=2	60%, N=6

Source: Lighting program data from Energy Trust of Oregon

Figure 54. Percentage of Existing Watts Saved by T5 fixture installations, 2008-2009

   - RECOMMENDATION: **Consider Retrofitting Industrial and Warehouse Applications with more efficient Metal Halide Lamps**. Despite the increase in the use of linear fluorescent in high bay applications, innovation of metal halide lamps has continued, and newly-available ceramic metal halide

[1] www.gelighting.com. Comparison of GE254MVPS90-F (HO) and GE228MVPS-A (regular) ballast input power, and initial lumens from 835 lamps.

lamps may allow cost-effective retrofit of more high-bay applications, using a simple lamp retrofit. See http://news.thomasnet.com/fullstory/830796. For projects in which the entire fixture is replaced, modern T4 electronically ballasted metal halide lamps offer efficacies in the 120 lm/W range, which is significantly higher than either T5 or T8 lamps.

6. **Statewide Lighting EUI Reductions Appear to be Due In Part to Energy Trust Programs or Other Effects, Not Only Due to Code.** The reduction in statewide EUI from 2000-2005 (19%) is larger than the reduction in LPD (10%), which is consistent with the increased use of lighting controls having an effect (over the same period) that is of the same magnitude as the LPD reduction. Note, however, that the EUI data (from NW Council) is based on a model that includes a large margin of error due to various assumptions, so these figures should not be taken as conclusive. The reduction in statewide EUI is larger than would have been expected due to Code alone. Code requirements became approximately 18% more strict over the period 1998-2007, but of course only affected new and retrofit buildings, so Code alone cannot account for the 19% statewide reduction in lighting energy use.
7. **Use of Daylight Controls Has Become Much More Widespread.** Daylight controls are installed in over 10% of new construction floor area; a significant increase since 1998. Energy Trust's "Year of Controls" (2009) may have increased the use of controls further, over and above the levels shown in the (pre-2009) market data.
   - RECOMMENDATION: **Ensure Quality Design, Installation and Commissioning for Daylight Controls**. Daylighting controls are becoming more familiar to designers and contractors. However, research by HMG among others has shown that daylighting systems, especially in sidelit applications, suffer from serious problems with poor installation, commissioning, and decommissioning by occupants. Now that daylight controls are more prevalent, Energy Trust should ensure that trade allies and others are designing and installing controls effectively.

6.3 Market Actor Practices

8. **Knowledge of HP T8 is Now Widespread.** Market actors discuss high performance T8 with clients. Knowledge of high performance T8 among trade allies and other actors is widespread and is due mostly to lamp and ballast manufacturers and to Energy Trust.
9. **Contractors and Distributors Often Instigate Retrofit Projects**. Many times they also provide advice or technical input on fixture type selection, fixture counts, and layout., i.e., they don't just sell or install luminaires.
10. **Trade Allies Have Little Formal Lighting Training.** Despite their close involvement with the design process, contractors and distributors report that they have mostly not received formal lighting design training. To determine light

levels they rely on personal experience and discussion with clients more than on technical guidance.

- RECOMMENDATION: **Maximize Savings by Training Trade Allies to Tailor Lamps and Ballasts to Required Light Levels.** Energy Trust should discuss with Trade Ally Network members how frequently they check lighting designs against code and IESNA requirements (to avoid overlighting), and how often they use lighting layouts or ballast factors to optimize savings. This will determine whether there is an opportunity to improve their professional practice.
- RECOMMENDATION: **Learn From, and Work With Lighting Equipment Manufacturers to Provide Training.** Because equipment manufacturers reach market actors so effectively, Energy Trust should explore opportunities to work with manufacturers or learn from their methods. Manufacturers may welcome Energy Trust's involvement if it would help to increase attendance at their own training programs.

11. **Some Trade Allies Do Not Discuss Options for Going Beyond Code With Their Clients.** Many market actors proactively engage their clients in discussion about how to exceed code, but there is a significant proportion who do not. Energy Trust should seek to find out why. Most members of the Trade Ally Network are experienced in lighting and should be able to confidently discuss options for going beyond code with their clients, but it seems that they are taking this opportunity, on average, only 56% of the time). The high percentage of projects that reportedly go beyond code nevertheless, suggests that if trade allies and other market actors started these discussions more often, even more projects would probably end up going beyond code.
    - RECOMMENDATION: **Encourage Trade Allies to Routinely Discuss Going Beyond Code, When They Interact With Their Clients.** Energy Trust should consider additional training and collateral for trade allies and others to support conversations about going beyond code.
12. **In Industrial Buildings, Lighting Controls Are Very Commonly Used in New Construction, but not in Retrofit Projects**. Figure 34 and Figure 35 show that, among the market actors surveyed, lighting controls (especially occupancy sensors) are used in the majority of new-construction industrial floorspace, but much less commonly used in retrofit construction. T5 HO lamps are the most common retrofit lamp type in industrial applications, and all T5 ballasts are rapid start which makes the use of occupancy sensor controls very suitable.
    - RECOMMENDATION: Energy Trust should discuss, with market actors who specialize in industrial lighting, whether lighting controls are really less common in retrofit projects, and if so how they can cost-effectively be included. Bi-level occupancy sensing may be more appropriate than off-switching in industrial applications due to safety concerns.
13. **Added Capital Cost Is Overwhelmingly The Main Reason Why C&I Clients Back Away From Exceeding Code**. This suggests that incentives remain a good

choice for market transformation. However, some psychological research has found that incentives are not good catalysts for behavior change. Energy Trust should ensure that the latest findings from behavioral research (for instance, papers from the ACEEE Behavior conference) are used to optimize program marketing and delivery.

14. **Concern Over the Performance of Controls is *not* a Major Barrier to Adoption.** In general market actors and clients have concerns over the potential for controls to malfunction, but only around 30% of people cited this as a make-or-break issue for controls. Energy Trust's recent training and provision of information to contractors and distributors as part of the "Year of Controls" may be a factor in this increased confidence, although we did not ask this specific question.

6.4 Energy Trust Influence on the Market

15. **Energy Trust has had a Major Influence on the Adoption of HPT8.** Approximately one quarter of T8 lamps in retrofit projects are High Performance T8. Approximately 80% of respondents believe that Energy Trust was "a major" or "*the* major" influence on market adoption of high performance T8s.. Unfortunately we do not have data on national adoption rates for High Performance T8 lamps and ballasts for comparison of this trend.

7. REFERENCES

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APPENDIX A—MARKET ACTOR SURVEY INSTRUMENT

In this survey, if any question is not relevant to your work, just leave the answer blank

About You and Your Firm

1. **Please enter the tracking number that was sent with your email invitation to take this survey [MUST ENTER THIS BEFORE THEY MOVE ON]**
2. **SC1. Which of these activities does your company engage in? [CHECK ALL THAT APPLY]**
    1. Manufacture lighting equipment
    2. Represent lighting equipment manufacturers
    3. Sell lighting equipment wholesale
    4. Sell lighting equipment retail
    5. Install commercial or industrial lighting equipment
    6. Specify or advise on the design and layout or lighting equipment
    7. Provide lighting maintenance services
    8. Other (describe)
3. **5.0 Have you been through any of the following training courses? [CHECK ALL THAT APPLY]**
    1. Attended one or more courses run by a manufacturer
    2. Attended one or more courses run by BetterBricks Integrated Design Lab
    3. Taken the IES ED50 course
    4. Taken the IES ED100 course
    5. Taken the IES ED150 course
    6. Passed the NCQLP “Lighting Certified” LC exam
    7. Registered Architect
    8. Professional Engineer

9. Member of IALD
10. BS or MS degree specializing in lighting
11. Other (please describe)

4. On what percentage of projects does your company provide each of the following lighting services?

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Specification of light fixtures, lamps and/or ballasts											
Layout of light fixtures											
Computer modeling or visualization of lighting											
Specification of lighting control equipment[1]											
Layout of lighting controls											
Cost benefit analysis (payback, ROI, LCC)											
Commissioning of lighting controls											
Planned or scheduled maintenance of lighting equipment											

[1] when controls are used on the project

5. **1.6 Approximately, how many full-time employees does your company have in Oregon?**
    1. [NUMBER]
    2. [PREFER NOT TO SAY]
6. **1.7 Approximately, what percentage of all your work in Oregon is commercial and industrial lighting?**

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Check boxes

Lighting Approaches

7. **On what percentage of your projects do you have a discussion with your client about lighting projects that are better than code?**

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Check boxes

[COMMENTS]

8. **If you have worked with Energy Trust's program, would you have discussed lighting projects that are better than code with your clients if Energy Trust's program did not exist? [CHOOSE ONE]**
    1. No
    2. Yes, in a few cases
    3. Yes, in many cases
    4. Yes, in all cases

[COMMENTS]

9. What percentage of your projects actually end up being better than code?

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Check boxes

[COMMENTS]

10. When your clients decide to go better than code, what are the main reasons why? [CHECK ALL THAT APPLY]

1. Reduced life-cycle cost
2. Financial incentives
3. Reduced maintenance cost
4. Improved quality of the visual environment
5. Good citizenship
6. Other

11. When your clients decide NOT to go better than code, what are the main reasons? [CHECK ALL THAT APPLY]

1. Added capital cost
2. Added design cost
3. Added maintenance cost
4. Potential for project delays
5. Uncertainty of performance of equipment
6. Reduced quality of the visual environment
7. Other (describe)

12. 4.0b How do you determine the target illuminance levels and lighting power densities in your designs? [CHECK ALL THAT APPLY]

1. Oregon Code
2. IESNA recommendations
3. Customer specifications
4. Previous personal experience
5. Better Bricks or utility energy efficiency program requirements
6. Other (describe)

13. 4.2 How often, if at all, would you say you use each of the following methods in your commercial or industrial lighting business?

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Standard layouts or ”templates”											
Average room illuminance “Lumen method” calculations						**Check boxes**					
Radiosity computer models (e.g., AGI32, Genesys)											
Measurements from a hand-held light meter											
Monitoring or other automated data collection											

14. Are you familiar with the term “High Performance T8” lamps and ballasts? [CHOOSE ONE]

1. No
2. Yes, I’ve heard of it
3. Yes, and I know what it means technically
4. Yes, I know what it means and I discuss it with clients

[COMMENTS]

15. From where have you obtained information about “High Performance T8” lamps and ballasts? [CHECK ALL THAT APPLY]

1. Energy Trust
2. lighting contractor Network
3. BetterBricks
4. Utilities

5. Lamp and ballast manufacturers
6. Other (describe)

16. How much influence do you consider Energy Trust to have had in the recent adoption of High Performance T8 lamps and ballasts in Oregon? [CHOOSE ONE]

1. No influence
2. Energy Trust was a minor influence
3. Energy Trust was a major influence
4. Energy Trust was the most important influence

[COMMENTS]

Lighting Practices

17. Are more than 10% of your lighting projects new construction? [IF YES SKIP TO NEW CONSTRUCTION LAMP TYPES QUESTION BELOW, IF NOT SKIP TO RETROFIT YES/NO QUESTION]

18. From the table below, please select three building types that you commonly work with, or have expertise in. For each of the three, thinking about NEW CONSTRUCTION projects, please estimate what percentage of all the fixtures had the following lamp types

	"High performance" or "super" T8	Regular T8	HO (high output) T5	Regular T5	Incandescent	HID	other
Offices	Percentage of fixtures						
Schools (k-12)							
Warehouses							
Grocery stores							
Assembly							
College/university							
Health Services							
Hospital							
Multifamily residential							
Industrial							
Institutional							
Lodging							
Restaurant / Bar							
Retail							

19. For the same three building types, still thinking about NEW CONSTRUCTION projects, please estimate what percentage of fixtures are typically controlled by each type of lighting control

(Note: May add up to more than 100% if multiple controls are used)

	Multi-level manual switches (“bi-level”)	Manual dimming controls	Occupancy sensors	Timeclock control	Daylight harvestin g
Offices					
Schools (k-12)					
Warehouses	percentage				
Grocery stores					
Assembly					
College/university					
Health Services					
Hospital					
Multifamily residential					
Industrial					
Institutional					
Lodging					
Restaurant / Bar					
Retail					

20. **Are more than 10% of your lighting projects retrofits or equipment upgrades? [IF YES SKIP TO RETROFIT LAMP TYPES QUESTION BELOW, IF NOT THEN SKIP TO Q23]**

21. **From the table below, please select three building types that you commonly work with, or have expertise in. For each of the three, thinking about RETROFIT projects, please estimate what percentage of all the fixtures had the following lamp types**

“High performance” or “super” T8	Regular T8	HO (high output) T5	Regular T5	Incandescent	HID	other

Offices	Percentage of fixtures
Schools (k-12)	
Warehouses	
Grocery stores	
Assembly	
College/university	
Health Services	
Hospital	
Multifamily residential	
Industrial	
Institutional	
Lodging	
Restaurant / Bar	
Retail	

22. For the same three building types, still thinking about RETROFIT projects, please estimate what percentage of fixtures are typically controlled by each type of lighting control

(Note: May add up to more than 100% if multiple controls are used)

	Multi-level manual switches ("bi-level")	Manual dimming controls	Occupancy sensors	Timeclock control	Daylight harvestin g
Offices					
Schools (k-12)					
Warehouses	percentage				
Grocery stores					
Assembly					
College/university					
Health Services					
Hospital					
Multifamily residential					
Industrial					
Institutional					
Lodging					
Restaurant / Bar					
Retail					

23. If you have worked on projects in which Energy Trust provided incentives for High Performance T8 lamps, how many of those projects would have gone ahead with T8 lamps even if the incentives had not been available?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
		Check boxes								

[COMMENTS]

24. 3.6 How often do you find that the light fixtures that *actually* get installed differ from the original specification?

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
		Check boxes								

[COMMENTS]

Controls

25. When you work with outdoor lighting (except streetlighting), how often do new outdoor fixtures have the following controls?

	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Motion sensors			Check boxes								
Photocontrol											
Timeclock control											

[COMMENTS]

26. 5.7 When you're discussing the use of lighting controls with clients, which of the following issues can *make or break* the client's decision to specify or purchase the controls? [CHECK ALL THAT APPLY]

1. Ongoing re-commissioning/re-tuning costs
2. Potential for equipment failures
3. Potential that users will override or decommission *occupancy sensors*.
4. Potential that users will override or decommission *daylighting controls*
5. Improvement in the visual environment
6. Degradation of the visual environment
7. Other (describe)

27. **If you have worked on projects in which Energy Trust provides incentives for lighting controls, how many of those projects would have gone ahead with controls even if the incentives had not been available?**

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
		Check boxes								

[COMMENTS]

28. **How often do you find that the lighting controls that *actually* get installed differ from the original specification?**

0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
		Check boxes								

[COMMENTS]

Trends

29. **2.1 How has your lighting business changed in the past three years as a result of developments in lighting industry and technology?**

    [TEXT]

30. **2.2 How do you think your lighting business is likely to change over the next three years in response to changes in lighting industry and technology?**

    [TEXT]

31. **6.3 What sources do you typically use to keep up to date on new lighting technologies and design trends? [CHECK ALL THAT APPLY]**
    8. Professional organizations, If so, which ones? Provide check list. local meetings? regional events? national events?
    9. Updates from manufacturers (emails? newsletters? trainings?)
    10. Trade magazines, if so, which ones? professional journals? web resources?
    11. Trade shows (e.g. Lightfair), if so, which ones? how regional?

12. BetterBricks Integrated Design Labs
13. Other

32. What services or information could Energy Trust provide to help you to market energy efficient lighting equipment?

[TEXT]

APPENDIX B—EXPERT INTERVIEWS: TRADE ALLY NETWORK 'TOP PERFORMER' INTERVIEW GUIDE

Discussion Guidelines and Purpose

The purpose of this discussion is to get expert input on the regional lighting market structure and gain insights on market trends for promising technologies, their challenges and associated barriers. The information gathered, along with additional expert interviews, will assist us in developing specific, relevant and/or quantifiable questions for the Market Actor surveys. This meeting with industry experts - the top performers from the Lighting Trade Ally Network - is an excellent opportunity to conduct a group expert interview and develop an initial relationship with these people, so that we can contact them later for additional information.

The structure of the meeting is intentionally kept relatively loose, so that the meeting participants can share with us their knowledge and opinions of the market without any presupposed restrictions imposed on our part. The topics and prepared questions (that we will only ask if necessary) are designed to help the respondents think through the relevant issues associated with the technologies and available products and services.

As an interview guide - as opposed to a survey instrument - this document assists the interviewer (discussion lead) explore all relevant topic threads that individuals may bring up, if it appears that doing so will help us better answer the primary questions. We will attach more value to discussions that address specific technologies' benefits and challenges, rather than responses that are generalized views of the overall lighting market, and will lead the discussion in that direction. We will pay attention to the group dynamic and make sure that the topics being discussed engage most of the attendees, instead of only a few.

Based on the results of this meeting and other expert interviews we will develop Market Actor Survey questions on:

- Market penetration and market trends for specific technologies
- Barriers and opportunities for these technologies
- Energy savings and non-energy benefits of these technologies

Introduction

We will introduce our selves and provide a very quick overview of the overall project and the purpose of the conversation with the trade allies, as described in the following sections.

Purpose of the Project

This will be a very short description of the Energy Trust project to provide them the larger picture context of why we are meeting with them.

What

- Give Energy Trust a snapshot of the C&I lighting market in Oregon

Why

- Allow Energy Trust to assess opportunities for improving programs, and where to get more savings

When

- Expert interviews—now until beginning of August
- Market Actor Survey—during August
- Report to Energy Trust September 30

Purpose of this Discussion

We will set the stage for what we expect from the discussion by quickly outlining what topic areas we will discuss in the context of the technologies, both common and emerging.

- Confirm "common" practices/products
- How is product performance described or categorized?
- What are the current big opportunities for energy savings?
- Discuss "promising" practices/products
- New technologies, new applications, new approaches to design or procurement
- Are there barriers to achieving savings?
- How can these barriers be avoided?
- How do technologies get procured successfully?
- Product volume data
- From trade allies?
- What can other distributors or contractors provide us with?

Review Procurement Process

Brief overview of the lighting procurement process as determined from the 2000 NEEA Lighting Market Assessment conducted by Xenergy. The purpose of presenting the flow diagram is to confirm with the trade allies, and to verify a similar market flow for controls or other emerging technologies.

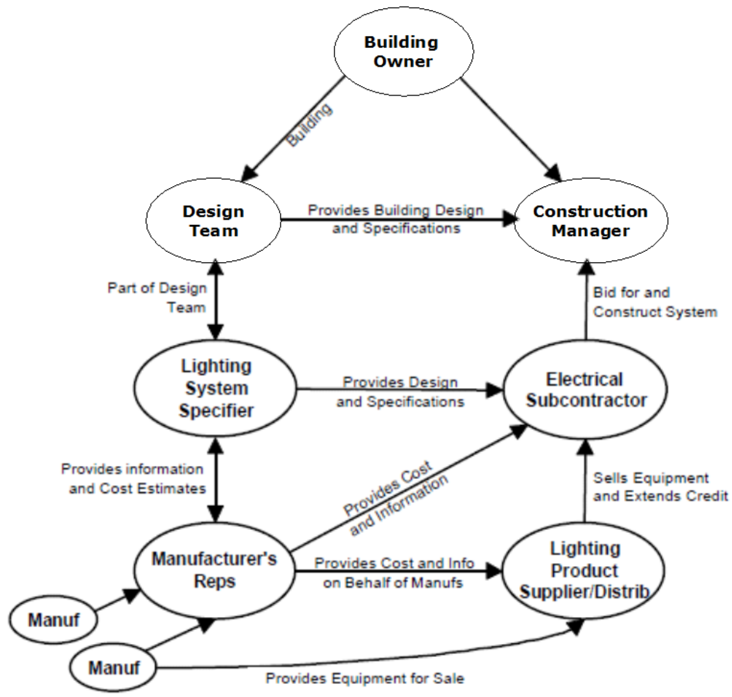


Figure 55: Lighting Procurement Schematic

At the start of the discussion we will spend very little time on this diagram, but will reference as necessary when talking about specific technologies.

Common Products

We will start by confirming common practice and products, elaborating on new developments within common technologies. The products are listed in this section. We will be sure to touch on all the products but will defer to the flow of the conversation on how much time is spent on each product/topic. For each of the products, we will ask the following questions:

- How are different levels of efficiency described?
- How is it procured?
- Which building types/applications?
- If necessary, we will press on specific barriers including:
- Lack of integration
- Lack of end user demand for advanced lighting
- Lack of professional knowledge

- Degree of specialization
- Distributor disincentive to promote advanced lighting and controls technology

The questions will apply to the following technologies

Linear Fluorescent Lamps

- T8, including variations in lamp wattage and ballast factor. Mention new Federal standard requiring high performance T8
- T5
- efficient fixtures
- alternatives such as cold cathode, LED for niche applications

HID Lamps

- Pulse start
- reduced wattages
- Alternatives to HID such as T5, induction, and where these are applicable

Incandescent Replacement Lamps

- CFL. Mention new Federal standard requiring high performance reflector lamps
- ceramic metal halide
- LED
- cold cathode

Controls

- occupancy sensors
- multi-level switching
- dimmable ballasts
- addressable ballasts
- EMS/scheduling
- smarter wiring setups and smarter lighting layout
- day lighting
- controls for exterior lighting

Promising Technologies/Practices

We will lead the discussion into additional technologies and applications based on the list of “promising” technologies identified in the 200 NEEA Lighting Market Assessment report. For each technology, we will start by asking the current status. The discussion can include both emerging technologies as well as new applications for existing technologies. We will not force the conversation to cover specific technologies, but will ask for clarification along the way and press for relevant information, steering away from areas that are not relevant to our study.. We will be sure to touch on all the products but will defer to the flow of the conversation on how much time is spent on each product/topic. As appropriate, we will ask similar questions regarding these technologies as we asked for “common” technologies, including:

- What are the current big opportunities for energy savings?
- Are there barriers to achieving savings?
- How do these technologies get procured successfully?

From NEEA Study 1999

- Lighting controls
- Lumen maintenance controls
- Photocontrols
- Scheduling controls
- Demand response
- Lighting control network
- Halogen IR
- Metal halide dimming

Promising Technologies in 2009

- Smarter lighting layouts
- Templates?
- Reducing light levels to IES minimum
- Design templates
- Reducing light levels below IES minimum
- Task/ambient

Product Data Collection

We will save time at the end of the discussion (not too late to lose their participation) to get their input on whether we can collect specific data during our telephone survey. we will be very careful not to call it sales data or market share data. We are not asking them to provide the information to us during the session, but rather asking whether it is data they would be able to provide, whether it is data they think other trade allies can provide, and how we might structure the request to get the data we want. We will specifically ask:

14. Who can (will) provide breakdown of product volumes? This could be members of the trade ally network, or others in the industry.

    Lamps by wattage

    Ballasts by BF and power draw

    Controls

15. Who (if anyone) will know where products are installed?

    Building type

    Space type

16. Is this type of data available?
17. Will we be able to get this level of data from our survey
18. If they are willing and able to provide this information to us, we will follow up with them after the meeting.

APPENDIX C—EXPERT INTERVIEWS: TRADE ALLY NETWORK 'TOP PERFORMER' INTERVIEW NOTES

Current Technologies

Linear Fluorescent

T8 Ballasts and Lamps

The trade allies frequently install 'high performance' T8s. There was no clear response from the group regarding the criteria for 'high performance' T8s (in particular in terms of ballast factor, wattage). The group utilized the CEE (Center for Energy Efficiency) criteria to determine whether lamps meet the efficiency requirements of Energy Trust's programs and to determine which were considered 'high performance.' The group also utilized experience with individual manufacturers to determine whether a lamp was high performance. It was also mentioned that lumen output and ballast factor could be utilized. Some allies only stock CEE compliant fixtures.

The group discussion was regarding whether Energy Trust programs should allow or encourage change out of existing T8 lamps for lower wattage without changing the ballast. In the past, there were issues of whether lamps were always compatible with ballasts, which prevented them from rolling out further incentives. The trade ally group mentioned that from their experience, in some cases, low wattage lamps were subject to flicker caused by cool, conditioned air flowing past the lamp. In addition, lower wattage T8s can only be run on instant start (i.e. not rapid or programmed).

Lower wattage 4' T8 lamps are preferred—32 Watt T8 lamps are rarely used. Very rarely do the trade allies replace T8 fixtures with lower wattage lamps, as the new lamps may not be compatible with the existing ballasts.

- Question—do you describe T8 ballasts according to ballast factor?
- No. People don't usually use BF, but 700/800 series functions as a proxy for BF, because 700 series is not high performance, 800 series can or cannot be high performance.
- Question—what's the best way to ask about T8s in the survey?
- Can't ask whether it's "high performance" because contractors won't know what you mean. Instead ask whether it's high or low lumens (T5), or ask 800 or 700 series for fluorescent.
- The "top performers" are an anomaly—90% of our products are 800 series .

T8 Fixtures

When completing T8 retrofits, the trade allies do not put in new fixtures, unless the fixture efficiency cannot be improved. Fixture efficiency is not commonly studied unless completing a substantial retrofit or new construction project.

Some trade allies replace the reflectors before they replace the entire fixture (troffer). The performance spec for reflector is typically 91% or higher (note that this must be the reflectance of the material, not the efficiency of the reflector). Many trade allies do not utilize luminaire efficiency (because it's difficult to determine the efficiency of old fixtures, and the majority of projects are retrofits).

T5

Trade allies distinguish between standard and high output T5s. This distinction breaks down mostly by space type—office lighting and wallwashers utilize standard output, whereas by contrast warehouses and uplighting utilize high output.

A frequent upgrade for all trade allies is from T8 to T5. Examples of why this would not happen include: 1) T5s have only one ballast factor 2) Most T5s utilize program start ballasts which are more expensive 3) T5 lamps are shorter which necessitates a lamp holder extension if one is retrofitting into the same fixture.

The next frontier for T5s include bi-level lamps for office applications.

HID Lamps

Rather than reducing the wattage of HIDs as part of a retrofit, trade allies change HID lamps out for fluorescents. Reducing HID wattage can be tricky in industrial applications due to the risk of not providing enough light. HIDs have a high rate of lumen depreciation. In high-bay retrofits, HIDs are replaced with T5s rather than with new HIDs. One trade ally suggested changing the HID reflector to produce more downlight (rather than uplight).

Incandescent Replacement Lamps

Trade allies replace incandescent lamps with halogen, halogen IR, self-ballasted ceramic metal halide, cold cathode, and LED lamps. Choice depends on application, wattage, and hours of use. Cold cathode is an emerging technology, currently existing for low wattage applications (up to 8W) with dimmable lamps from manufacturer Ushio. Self ballasted ceramic metal halides are now available in the range of 25 W to 150 W. As was discussed above, LEDs are still cost-prohibitive in most applications.

Controls

Photocontrols are commonly used (dimming or dual level with either bi-level circuit or step ballasts). Occupancy sensors are also common, and trade allies choose either manual-on and auto-on based on application.

Trade allies distinguish between commercial and residential grade controls, and do not recommend utilizing residential grade controls as the quality of the components are very poor.

Trade allies do not typically utilize centralized controls. They are very common on new buildings (with scheduling), but less so on retrofit.

Some trade allies commission their controls. Some allies noted that some of the controls they utilized are pre-commissioned by the manufacturer and therefore come commissioned 'out-of-the-box.'

Recommissioning and load shedding is a new frontier. Load shedding controls can be retrofitted, but is a costly process and often existing building wiring is not conducive to this.

Promising Technologies

We asked the group about some of the technologies that were promising technologies in the 2001 NEEA study.

"Lumen maintenance" controls are no longer utilized. Linear fluorescent lamps maintain lumen output quite well over time.

Infrared Halogen is used in retail, but eventually LEDs will take over.

Metal halide dimming technology has come in and out of the market but has not had a lasting presence. Trade allies argued that it is better to remove metal halide (as it is less efficient than other fixture types), rather than adding dimming.

The majority were not convinced that LEDs are a currently market ready. A number of very inexpensive and poor quality LEDs are available online from unverified manufacturers. One participant noted that some LEDs are claiming to be UL 'Rated' rather than UL 'Listed,' which signifies that they are not necessarily compliant. Currently the ENERGY STAR LED fixture list contains only three entries, and recent CALiPER tests showed that those fixtures are not as efficacious as claimed.

The group agreed that until major manufacturers come out with a comprehensive range/series of fixtures, they will not promote them. A few exceptions exist, including downlighting and street lighting where the group believed that LEDs had been proven. One trade ally believed that if chosen correctly LEDs have many useful applications.

The Energy Trust programs have created a list of protocols for LED incentives through the custom lighting track. The DOE is working with LED manufacturers to ensure that LEDs are positively received by the industry. The likelihood that the trade allies would utilize the incentives were discussed by the group.

Lighting Practices and Services

The trade allies attempt to get further savings beyond simple change-out of ballasts, i.e. they get involved with reducing lamp or fixture counts in overlit spaces, and in optimizing layouts. The spaces which trade allies work with frequently are overlit.

Trade allies emphasized, however, that quality and visual comfort are important. Trade allies often use illuminance meters, and make decisions based on measured illuminances, end user feedback, an understanding of the lighting task, lighting quality issues, and hours and patterns of use (lighting design with a small 'd').

The trade allies work actively with the users (customer) to determine the best solutions and do a lot more face to face work with end users than other contractors and distributors. The trade allies also utilize IES (Illuminating Engineering Society) Guidelines to help determine appropriate illuminance levels for each application.

Also, trade allies actively seek projects—jobs often happen because the ally suggests them to the customer rather than vice versa.

Lighting layout and basic design is a potential new frontier for programs. The group discussed the NEEA Integrated Design Lab (IDL) lighting design templates and how they could be applied to trade ally work. Though in regard to retrofit projects one trade ally mentioned their hesitance to change layout due to potential problems/added cost of re-wiring, ceiling tile, asbestos, etc.

Trade allies frequently change the lamp type rather than trying to make an inefficient lamp more efficient. For example, rather than change out an HID for an HID, they would change an HID for a T5. Trade allies sometimes change the reflector before changing out the entire fixture.

There was an increase in the use of controls in the last cycle. This was largely due to the Oregon energy code change.

Commissioning incentives and training could be a next frontier for lighting retrofits and energy efficiency programs. In some cases allies undertake commissioning even if there is Energy Trust incentive for commissioning.

Load shedding and recommissioning is a potential new frontier. Load shedding will require dedicated wiring.

Lighting Power Density (LPD) calculations were not frequently completed among the trade ally group as their focus is primarily on retrofit projects (by contrast, new construction does utilize LPD calculations). LPDs are calculated, however on program application forms. The only time LPDs are calculated is when a tenant improvement has occurred or a project has changed use.

APPENDIX D—EXPERT INTERVIEWS: ENERGY TRUST PROGRAM MANAGER INTERVIEW GUIDE

Overview

The purpose of these interviews is to get specific and/or quantifiable information about the Energy Trust's Commercial and Industrial Lighting programs.

These interviews are intended to help HMG better understand the program and the relationship between Energy Trust's programs and the market actors, so we can design an effective Market Actor Survey instrument.

The information gathered from program staff, along with other expert interviews, will assist us in developing specific and relevant questions for the Market Actor Surveys. In-person interviews with program staff are an excellent opportunity to understand program specific details. We hope that the interviews will give program staff an opportunity to give their frank opinions about program offerings and procedures, which will help us to understand how the programs function. Note that we will *not* be writing a program process review in our report.

The structure of the interviews is intentionally kept relatively loose, so that the program staff can provide the important details of the program without any restrictions being imposed on our part. The topics and prepared questions are designed to help the respondents think through the relevant issues associated with the program offerings and services. As an interview guide - as opposed to a survey instrument - this document helps the HMG interviewer to explore relevant threads that staff may bring up. Key topics that we will specifically ask the Energy Trust program staff are:

- How the programs work
- The kind of products (technologies) that are incentivized
- Where the majority of program savings come from
- What emerging opportunities the program is or is not taking advantage of
- How the program fits into the overall lighting market and procurement processes

Introduction

We will introduce ourselves and provide a very quick overview of the overall project and the purpose of the conversation with the trade allies, as described in the following sections.

Purpose of the Project

We will provide a very short description of our project to provide them with the larger context of the study.

What

- Give Energy Trust a snapshot of the lighting market in Oregon

Why

- Allow Energy Trust to assess opportunities for improving programs, and to identify where to get more savings

When

- Expert interviews—now until end of July
- Market Actor Survey—during August
- Report to Energy Trust September 30

Purpose of this Interview

We will set the stage for what we expect from the discussion by quickly outlining what topic areas we will discuss in the context of the technologies, both common and emerging:

We're conducting C&I lighting market research for Energy Trust to identify and document successes and the identify additional program opportunities. This interview should take 20-30 minutes. The answers you give may be used in the study report but your name will not be associated with specific information.

Personal Details

Collect some personal details:

- What is your job title?
- What does your job typically involve?
- How long have you been at this job?

Program Process

- Do any lighting project leads come from outside the Trade Ally Network? If so where do they come from?
- How are incentive levels determined, and are they appropriate?
- How is the program tracked? Are some things not tracked that should be?
- How do you expect this program to develop over the next year, the next five years?
- What guidance is available to specifiers and installers through the program or elsewhere?
- Do you gather post-installation data on the effectiveness of the measures?

Incentivized Products & Technologies

- Are any lighting services provided by the program in addition to incentives?
- Which technologies give rise to the most savings?
- Which technologies are the easiest to promote?
- Which technologies are the most cost-effective to promote?
- Do you find that some technologies are difficult for specifiers or installers to understand?
- Do you find that some products are more or less successful at achieving savings?
- Do you find that some participants are more or less successful at achieving savings?

How Does the Program Fit into the Overall Lighting Market?

- How much is the program driven by installers? Distributors? End-users? Others?
- Are there specific building types or business sectors that you find particularly hard to reach?
- Are there types of distributors or contractors that you find hard to reach?
- Are there types of specifiers or designers that you find hard to reach?

- What activities do you undertake to ensure that lighting projects optimize savings and remain enrolled through completion?
- How do you coordinate with NEEA BetterBricks and other programs such as LEED and ENERGY STAR?
- Do program participants take advantage of BETC or other incentives?

APPENDIX E—ENERGY TRUST PROGRAM DATA ON COMMERCIAL PROGRAMS

The program data in this appendix was provided to HMG by Energy Trust in November 2009, to supplement the market analysis conducted in this project. It covers Energy Trust's Existing Buildings (EB) program, which is responsible for the majority of lighting incentives.

Lighting Tool Data Analysis

November 3, 2009

Prepared by Matthew Taylor

The following memo provides a summary and analysis of commercial lighting projects performed through Energy Trust of Oregon's Existing Buildings (EB) program. The data was extracted from the individual projects' lighting tools obtained from the program's management contractor.

A complete analysis of all historical lighting projects was not possible, as all project files have not yet been obtained. A breakdown of total Energy Trust commercial lighting projects and number of projects' lighting tools used in this analysis, by year, is shown below. Energy Trust lighting projects are defined as projects completed through the EB program that involved a lighting or lighting controls measure, either custom or prescriptive.

Table 1. Lighting Projects by Year

Year	N Projects	N Lighting Tools Analyzed	% Projects Used in Study
2004	284	0	0%
2005	471	0	0%
2006	122	28	23%
2007	440	148	34%
2008	542	505	93%
2009	344	313	91%
Total	*2,203*	*994*	*45%*

Where appropriate, projects completed during the program years 2008 and 2009 are analyzed independently from previous projects. The high percentage of projects represented in the dataset allow for more confidence in the characterization of the program's lighting projects. Additionally, the most recent projects have the most relevant information about the continually evolving program.

Lighting equipment, both existing and replacement, were categorized into broad technology groups for analysis. Table 2 below displays the number of instances a lighting technology was used as a replacement lamp, the total kilowatts installed of that lamp type (quantity of bulbs x wattage), the percentage of total installed watts of the dataset, and the percentage of the dataset's savings achieved by that technology. High Performance T8 technology achieves the majority of savings and is installed the majority of the time, followed by T5, CFL, and T8 technologies.

Table 2. Installed Wattage by Light Type

Light Type	Number of Measures	Total kW Installed	% of Installed kW	% of Savings
T8 High Performance	3,121	6,667	64.7%	61.6%
T5	446	2,319	22.5%	20.1%
CFL	706	569	5.5%	9.4%
T8	317	392	3.8%	3.2%
HID	68	228	2.2%	1.7%
LED	56	20	0.2%	1.7%
T12	8	9	0.1%	0%
High Pressure Sodium	13	15	0.1%	0%
Cold Cathode	27	9	0.1%	1%
Exit Signs	147	5	0.1%	1.3%
Other	48	71	0.5%	0%
Total	*4,957*	*10,304*	*100%*	*100%*

Table 3 below displays the percentage of the most commonly installed light types by the type of lights they were replacing. The following three combinations of an existing technology group being replaced by a given technology group are responsible for two thirds of the EB program's electric savings from lighting measures:

- High Performance T8 lights replacing T12 lights achieved 30.8% of savings
  - Primarily 1 for 1 replacements of 4' lights for 4' lights
- High Performance T8 lights replacing metal halide (HID) lights achieved 23.0% of savings
  - 81% and 14% of replacements are for 400W and 250W lights, respectively
  - Approximately 50% of such replacements are in warehouses
- T5 lights replacing HID lights achieved 13.1% of savings
  - 82%, 8%, and 6% of replacements are for 400W, 1,000W, and 250W lights, respectively
  - Approximately 45% of such replacements are in warehouses

Table 3. Installed Light Types by Replaced Light Types, all years

Replaced Type	Replacement Type					
	T8 (HP)	T5	CFL	T8	HID	Total
Custom	1.3%	2.1%	0.6%	2.0%	0.0%	1.6%
HID	29.9%	61.7%	2.4%	10.5%	35.2%	34.8%
High Pressure Sodium	1.8%	21%	0.9%	0.5%	26.0%	6.9%
Incandescent	0.5%	0.6%	91.8%	0.5%	11.2%	6.1%
Mercury Vapor	0.4%	0.7%	1.0%	0.3%	27.6%	1.1%
T12	54.0%	9.8%	2.0%	73.8%	0.0%	40.2%
T8	11.9%	2.3%	0.1%	12.3%	0.0%	8.7%
Other	0.2%	1.8%	1.2%	0.1%	0.0%	0.6%
Total	100%	100%	100%	100%	100%	100%

% of installations that are one for one quantity	93%	67%	94%	95%	82%	91%

Table 4 shows the percentage of savings of 2008 and 2009 lighting measures that were achieved by combinations of replaced and replacement technology. As projects from these program years dominate the dataset, the percentage of savings achieved by various lighting technologies in 2008 and 2009 is very close to that of the program across all years, as shown in the last column of Table 2.

Replacements of HID lighting (almost exclusively metal halide) account for 39% of the program's savings, and are primarily replaced with High Performance (HP) T8s and T5 technology. A further one third of the programs savings in the last two years are coming from replacing T12 technology (primarily with HP T8s).

Table 4. Installed Light Types by Replaced Light Types, % of total savings, 2008-2009

Replaced Type	**Replacement Type**					
	T8 (HP)	**T5**	**CFL**	**T8**	**HID**	**Total**
HID	24.5%	11.9%	0.6%	0.9%	0.7%	39.1%
High Pressure Sodium	2.5%	4.4%	0.1%	0.1%	0.1%	7.5%
Incandescent	0.5%	0.3%	9.0%	0.0%	0.5%	13.3%
Mercury Vapor	0.3%	0.1%	0.2%	0.0%	0.3%	1.0%
T12	28.7%	2.2%	0.1%	2.3%	0.0%	33.5%
T8	4.0%	0.3%	0.0%	0.0%	0.0%	4.4%
Other	0.8%	0.1%	0.1%	0.0%	0.1%	1.2%
Total	61.3%	19.3%	10.1%	3.4%	1.7%	100%

Of interest is the frequency with which lighting retrofits reduce the number of bulbs and fixtures used in a given space, as they imply increased savings beyond that of the transition to more efficient technology. Detailed information for each measure classification makes further analysis possible and is discussed below by lighting technology. Each of the replaced/replacement combinations accounting for large percentages of savings are looked at separately, as each light type has unique classifications associated with the technology.

High Performance T8 Fixture Replacements for T12s

Measures involving the replacement of T12 fixtures with HP T8 fixtures account for approximately one third of replaced wattage. Of the 2,641 such replacements, 95% replaced existing fixtures with an equal number of fixtures. Table 5 below displays the percentage of replacements that are one-for-one in quantity of fixtures, one for one in the number of lamps in the fixtures, and where the replaced and replacement bulbs are of the same size.

Table 5. Measures Involving HP T8s Replacing an Equal Number of Same Size T12 Bulbs

Number of Lamps in Fixture Replacements	**N**	**%**
Increase in Number of Lamps	7	<1%
Same Number of Lamps	1,274	48%
Decrease in Number of Lamps	544	21%

These percentages are the same when considering only those projects completed in the program years 2008 and 2009 (85% of these measures were performed in those years). It is important to note that data on fixtures presents only the potential number of lamps, and not the actual capacity used. The data says nothing about what percentage of fixture capacity was in use before or after the equipment replacement.

High Performance T8 Fixture Replacements for HIDs

Approximately 25% of savings from 2008-2009 commercial lighting projects came from HP T8 replacements of HID lamps. In this instance, the only data available on the Metal Halide lights being replaced was the wattage of the lights and the quantity of fixtures. The ratio of replacing to existing watts is shown below in Table 6, categorized by HP T8 fixture type and the most commonly replaced Metal Halide fixture types (they make up 96% of measures).

The percentage of such measures that involved the more specific fixture types appear in italics in the table below. Of these replacement types, 90% involve 4’ six lamp HP T8 fixtures replacing 400 watt metal halide fixtures, for which the installed equipment only uses 54% of the previously used wattage.

Table 6. Ratio of Replacement watts to Existing watts, 2008-2009

HP T8 Fixture Type	250 Watt	400 Watt	1000 Watt
4’ by 2 lamp	0.20 *<1%*	--	--
4’ by 4 lamp	0.41 *1%*	0.31 *2%*	--
4’ by 6 lamp	0.75 *<1%*	0.54 *90%*	0.35 *1%*

T5 Installations

Approximately 90% of T5 fixture installations during the years 2008 and 2009 were using high output (HO) T5 technology. Fixtures with more than 2 lamps were all HO, while 62% and 93% of 2-lamp and 1-lamp T5 fixtures were for HO lamps, respectively.

A comparison of the percentage of existing wattage saved by HO and regular T5 lights, in various applications, is shown below in Table 7 (included is the number of measures including such replacements). The table shows the reduced efficiency of HO T5 technology when compared to regular T5 technology.

Table 7. Percentage of Existing Watts Saved by T5 fixture installations, 2008-2009

Replacement/Replaced Combination	Regular T5	High Output T5
2-lamp T5 Fixture Replacing 2-lamp T12s	60%, N=14	43%, N=22
2-lamp T5 Replacing Incandescent	70%, N=3	44%, N=3
1-lamp T5 Replacing 1-lamp T12	87%, N=2	60%, N=6

T5’s replacing Metal Halide lights account for 12% of 2008-2009 commercial lighting savings. The following table shows the ratio of replacing to existing watts for the most frequent combinations of replaced and replacing fixture types. Approximately 79% of existing Metal Halide fixtures that are replaced with T5s are 400 watt fixtures, and are primarily replaced with 4 lamp HO T5 fixtures. The percentage of T5 for HID replacements that are specific fixture types is included in the tale.

Table 8. Ratio of Replacement watts to Existing watts, 2008-2009

HP T8 Fixture Type	250 Watt	400 Watt	1000 Watt
2-Lamp High Output	0.40 *<1%*	0.25 *<1%*	--
3-Lamp High Output	0.60 *3%*	0.40 *<1%*	--
4-Lamp High Output	0.64 *2%*	0.52 *59%*	0.43 *2%*
5-Lamp High Output	--	0.61 *3%*	--
6-Lamp High Output	--	0.65 *15%*	0.51 *6%*
8-Lamp High Output	--	--	0.41 *<1%*

High Performance T8 Replacements for Regular T8s

High Performance T8 fixtures replacing existing T8 fixtures accounts for approximately 6% of wattage replaced across all program years. Almost 87% of these measures involved an equal number of HP T8 fixtures replacing an equal number of existing T8 fixtures. The percentage of HP T8 for regular T8 replacements that involve the same quantity of fixtures, and the same number of same size lamps per fixture can be seen in Table 9 below. The percentages for the 2008 and 2009 program years are almost exactly the same as those across all program years, shown below.

Table 9. Measures Involving HP T8s Replacing an Equal Number of Same Size T8 Bulbs

Number of Lamps in Fixture Replacements	N	%
Increase in Lamps	0	0%
Same Lamps	36	23%
Decrease in Lamps	45	28%

Primary Installations Over Time

The following charts, Figures 1 and 2, show the percentage of watts installed by installed lighting type by year, and the percentage of watts replaced by replaced lighting type by year. The mix of replacement and replaced lighting types appears to have remained relatively constant over these four years. However, it is important to note that the dataset is missing a large portion of projects completed during the program years 2006 and 2007, as seen in Table 1 above.

Figure 1: Percentage of Replacement Watts by Light Type by Year

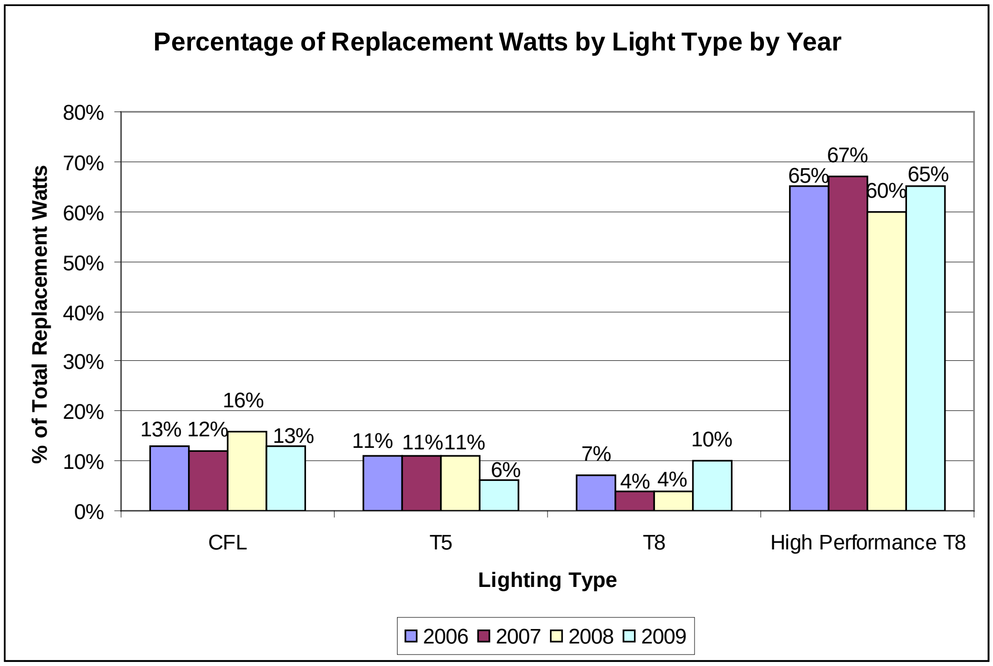
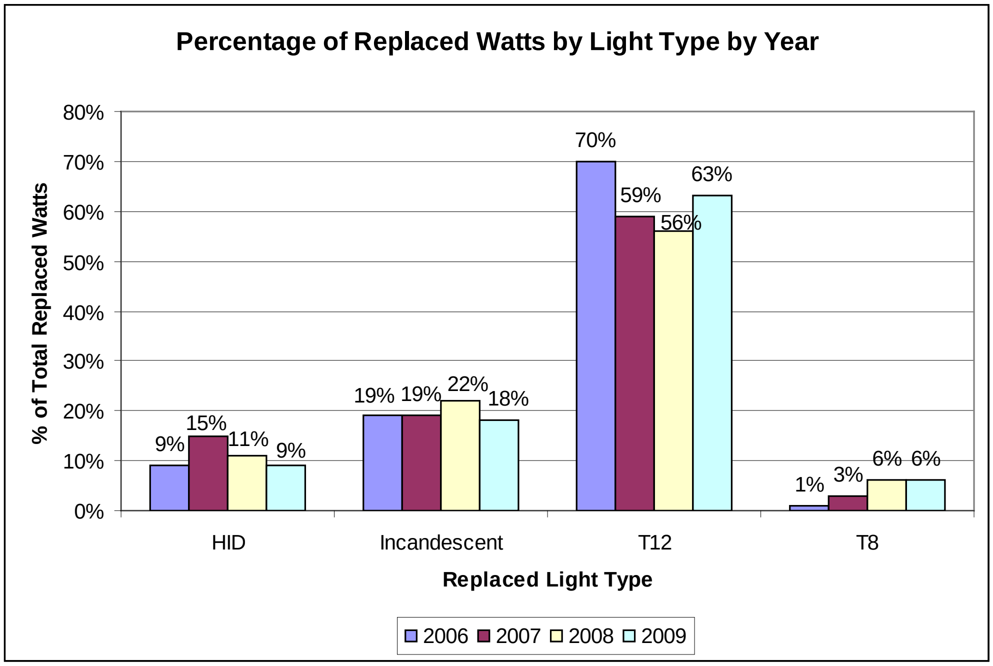


Figure 2: Percentage of Replaced Watts by Light Type by Year



Sector Specific Analysis

Information on a building's business type is consistently recorded in the lighting tools, allowing for analysis of commercial lighting measures by business classification. The majority of lighting savings come from retail and warehouse buildings, as shown below in Table 10.

Table 10. Installed Wattage by Building Type

Building Type	Number of Measures	Total kWatts	% of Installed Watts	% of Savings
Retail	1,023	3,300	32.0%	36.1%
Warehouse	741	2,649	25.7%	20.3%
Office	861	1,111	10.8%	7.5%
Education	814	757	7.3%	5.7%
Grocery	348	555	5.4%	7.5%
Lodging	145	414	4.0%	4.1%
Exterior	47	93	0.9%	2.0%
Restaurant	133	56	0.5%	1.1%
Manufacturing	23	27	0.3%	0.2%
Other	820	1,342	13.1%	15.3%
Total	*4,955*	*10,304*	*100.0%*	*100%*

The assumed operating hours of lighting for building types varied, typically ranging from 1,000 hours a year or less to 8,760 hours a year (24 hours a day, 365 days a year). The mean and median operating hours can be seen below in Table 11. Lighting in grocery stores has noticeably high operating hours, for which the overwhelming majority of replacements are T8s and high performance T8s.

Table 11. Average Operating Hours by Building Type

Building Type	Number of Measures	Mean Number of Hours	Median Number of Hours
Retail	1,023	4,908	4,982
Warehouse	741	3,870	3,203
Office	861	3,596	2,796
Education	814	2,670	2,520
Grocery	348	7,852	8,760
Lodging	145	3,861	2,555
Exterior	47	5,455	4,380
Restaurant	133	5,468	5,033
Manufacturing	23	5,002	4,321
Other	820	4,123	3,559
Total	*4,955*	*4,225*	*3,406*

Retail Sector

The 2009 Oregon Lighting Market Assessment showed the retail sector accounting for 32% of Oregon's total commercial lighting end use (112 of an estimated 350 aMW). As it was recommended that Energy Trust make special efforts to further reach the retail sector, data from 2008 and 2009 retail projects were further explored. During these program years retail lighting projects saved 1.86 aMW - 1.7% of the estimated 112 aMW used by lighting in the retail sector in 2009. These savings account for over one third of total savings from commercial lighting projects, primarily achieved by the replacement of the following technologies:

- 47% of kWh savings from the replacement of HID lamps
- 36% of kWh savings from the replacement of T12 lamps
- 9% of kWh savings from the replacement of Incandescent lamps

High Performance T8 and CFL installations were responsible for 84% and 10% of energy savings in the retail sector, respectively.

There still appears to be a large portion of the retail sector (we've saved 1.7% of their estimated 2009 lighting load) in Oregon that has not participated with Energy Trust. It is recommended that Energy Trust use data on retail establishments, from Sales Genie and Metro Scan property records, to identify large owners of retail buildings and facilitate further targeting of the retail sector.

Costs of Technology

Data on the installed cost of commercial lighting technologies was extracted from the lighting tool, and can be used to track the costs of such technology over time. Analysis can be done on specific fixture types within broader technology groupings, across different building types, and across program years. In this instance the most frequently installed fixture types, 4' 4-lamp HP T8 fixtures and 4' 2-lamp HP T8 fixtures, were examined over time (tables of N's for the various graphs can be seen in the Appendix).

Figure's 3 and 4 show the average cost of 4' 2-lamp and 4' 4-lamp fixtures, by ballast factor, over time.

Figure 3.

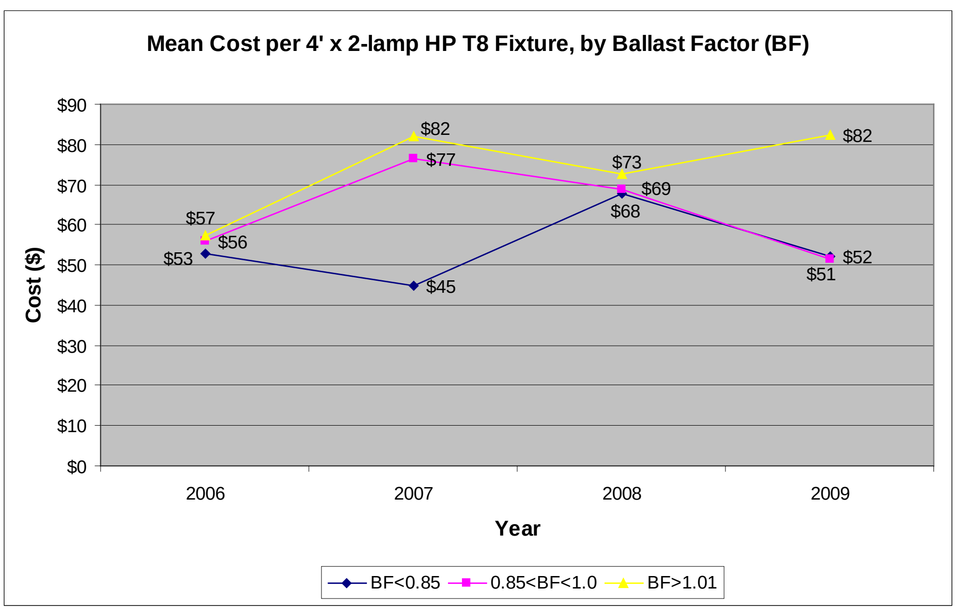
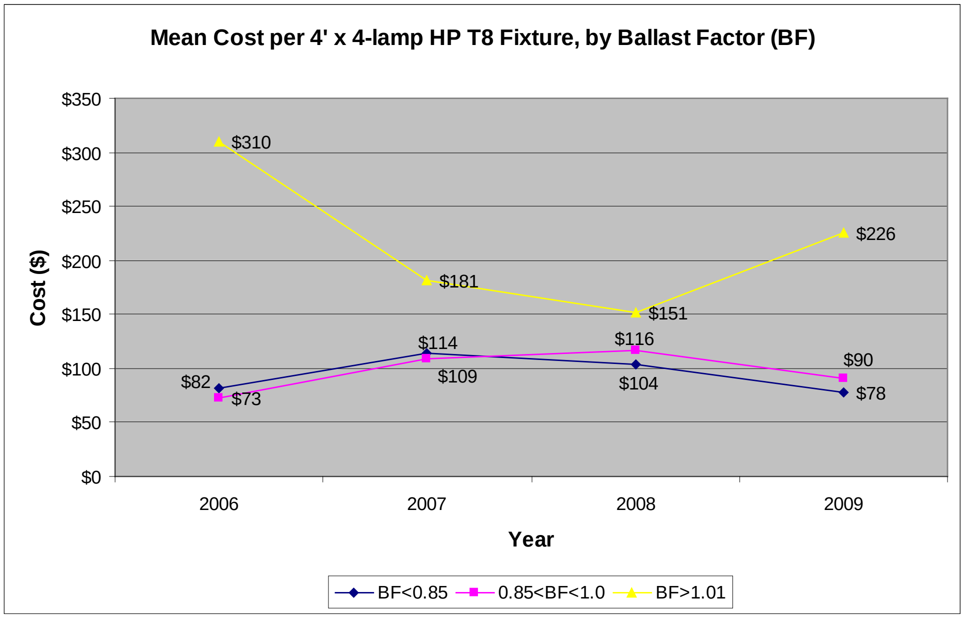
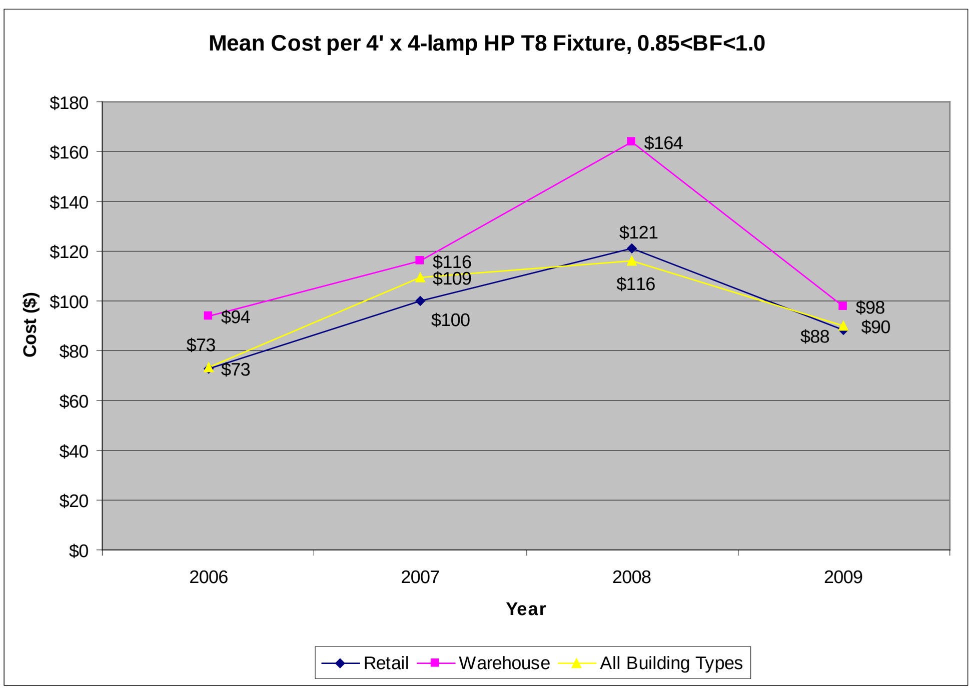


Figure 4.



There existed relatively large variations in both price per fixture and average price per fixture over time. It was proposed that the large variations of the cost of a given fixture type varied with the application setting and (or) the type of fixture they were replacing. Figure 5 shows the average cost of 4' 4-lamp HP T8 fixtures for all building types, warehouses, and retail locations. Comparisons of cost of replacing various existing lighting fixtures showed that installing 4' x 4-lamp HP T8 fixtures in a warehouse setting tends to be more expensive than in retail, office, or education buildings. The large increase in cost per fixture installed in warehouses in 2008 is attributable to a relatively large number of more expensive replacements for 400W Metal Halide fixtures in that year.

Figure 5.



Further analysis of costs of technology in various applications can be performed as deemed necessary. Where desired, further analysis should be performed.

Lighting Controls

Information on lighting controls was also collected from the lighting tools. The majority of the 7,085 controls installed, 70%, were fixture mounted occupancy sensors. A further 13% and 11% of installations were wall switches and ceiling mounted occupancy sensors, respectively.

A summary of the types of lights that are being controlled is shown in Table 12 below. The majority of controls are being installed on high performance T8 and T5 lights. Table 13 shows the percentage of total watts installed, by light type, which also had controls installed on them. Although T8 high performance lights have the majority of controls installed on them, just 11% of these types of installations have some form of control.

Table 12. Lights with Control Measures Installed, by Type

Light Type	**% of Lights Controlled**
T8 High Performance	55%
T5	24%
T8	10%
CFL	3%
HID	<1%
T12	<1%
Other	8%
Total	100%

Table 13. Percentage of Lighting Watts Installed, by Type, with Controls

Light Type	**% of Installed Watts Controlled**
T8 High Performance	11%
T5	34%
T8	27%
CFL	2%
HID	6%
T12	61%
Total	17%

Appendix

Number of Fixtures Installed, Figure 3

	2006	2007	2008	2009
BF<0.85	492	2982	6862	2743
0.85<BF<1.0	791	2186	5436	1357
BF>1.01	78	616	2539	201

Number of Fixtures Installed, Figure 4

	2006	2007	2008	2009
BF<0.85	638	1510	2752	737
0.85<BF<1.0	305	703	3887	899
BF>1.01	19	356	973	318

Number of Fixtures Installed, Figure 5

	2006	2007	2008	2009
Retail	297	166	2332	595
Warehouse	10	140	823	52
All Buildings	305	703	3887	899

APPENDIX F—ENERGY TRUST PROGRAM DATA ON INDUSTRIAL PROGRAMS

The program data in this appendix was provided to HMG by Energy Trust in November 2009, to supplement the market analysis conducted in this project. It covers Energy Trust's Productions Efficiency (PE) program.

Industrial Lighting Tool Data

November 9, 2009

Prepared by Matthew Taylor

The following report provides a summary of lighting measures implemented through Energy Trust of Oregon's Production Efficiency (PE) program. The data was extracted from 103 individual projects' lighting tools retained by program staff.

As the vast majority of project workbooks did not include project completion dates Table 1 below displays the breakdown of lighting tools used by the year the tool was prepared. The number of projects per year is based on unique Energy Trust PE projects involving the implementation of a lighting measure (custom or prescriptive), taken from the Energy Trust Fast Track database. The projects span the years 2006 through 2009, representing 28% of PE projects that involved lighting measures.

Table 1. PE Lighting Projects by Year

Year	N Projects	N Lighting Tools Analyzed	% Projects Used in Study
2004	1	0	0%
2005	39	0	0%
2006	41	11	27%
2007	77	32	42%
2008	124	34	27%
2009	84	19	24%
Missing	--	7	--
Total	*366*	*103*	*28%*

Both installed and existing lighting equipment were grouped by broad lighting technologies. The percentage of PE electric savings from lighting measures that were achieved by different replacement and existing technology pairings can be seen in Table 2 below. The majority of savings came from installing T5 fixtures, 44% and 27% coming from replacing Metal Halide (HID) and High Pressure Sodium fixtures, respectively. Instances of High Performance (HP) T8 fixtures replacing T12 fixtures accounted for an additional 14% of savings. These three replacement/existing technology pairings are discussed in more detail below.

Table 2. Installed Light Types by Replaced Light Types, % of total savings, all years

Existing Type	Replacement Type						
	T8 (HP)	T5	CFL	T8	HID	Other	Total
HID	6.7%	43.6%	0.0%	0.0%	0.2%	0.8%	51.3%
High Pressure Sodium	1.0%	27.3%	0.0%	0.0%	0.1%	1.3%	29.7%
Incandescent	0.1%	0.2%	0.2%	0.0%	0.0%	0.1%	0.6%
Mercury Vapor	0.0%	0.6%	0.0%	0.0%	0.1%	0.0%	0.8%
T12	13.7%	1.7%	0.0%	0.5%	0.0%	0.6%	16.6%
T8	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Other	1.1%	0.5%	0.0%	0.0%	0.1%	0.4%	1.0%
Total	21.5%	73.9%	0.4%	0.5%	0.5%	3.2%	100%

T5 Fixtures Replacing Metal Halide Fixtures

All instances of T5 installation in this dataset were for High Output (HO) fixtures. Although 80% of such replacements are for an equal number of Metal Halide fixtures, 15% and 5% of these measures increased and decreased the number of fixtures present, respectively.

Table 3 shows the percentage of existing watts saved when T5 fixtures replace either 400W or 1,000W Metal Halide technology. These were primarily 4, 5, or 6-lamp fixtures replacing 400 Watt Metal Halide Fixtures. As expected, 4-lamp T5 fixtures save a greater percentage of existing wattage than do 5 or 6-lamp fixtures when replacing a given size lamp fixture. To add context for the relative size of each replacement/existing technology pair, the table includes the percentages of T5 for Metal Halide watts installed by each grouping.

Table 3. T5 for Metal Halide; when same fixture quantity

Replacement Fixture Type	400 Watt Metal Halide		1000 Watt Metal Halide	
	% of Existing Watts Saved	% of Table Replacement Watts	% of Existing Watts Saved	% of Table Replacement Watts
4-lamp HO T5	49%	55.0%	78%	0.2%
5-lamp HO T5	36%	1.6%	--	--
6-lamp HO T5	24%	5.0%	67%	7.4%

Similarly, the following two tables, Tables 4 and 5, show the percentage of existing watts saved by lighting measures when the number of existing fixture is reduced or increased, respectively. As expected, savings increase notably when there is a decrease in the number of fixtures.

Table 4. T5 for Metal Halide; when reducing fixture quantity

Replacement Fixture Type	400 Watt Metal Halide		1000 Watt Metal Halide	
	% of Existing Watts Saved	% of Table Replacement Watts	% of Existing Watts Saved	% of Table Replacement Watts
4-lamp HO T5	66%	4.4%	--	--
6-lamp HO T5	35%	0.2%	73%	10.4%

Table 5. T5 for Metal Halide; when increasing fixture quantity

Replacement Fixture Type	400 Watt Metal Halide		1000 Watt Metal Halide	
	% of Existing Watts Saved	% of Table Replacement Watts	% of Existing Watts Saved	% of Table Replacement Watts
4-lamp HO T5	34%	13.5%	44%	0.5%
6-lamp HO T5	--	--	50%	1.2%

T5s replacing High Pressure Sodium

The vast majority of instances where T5 technology is used to replace High Pressure Sodium lights involved the replacement of 400W light fixtures using 4 and 6-lamp T5 fixtures. Almost 100% of these involved no change in the fixture quantity. Table 6 shows that using 6-lamp in place of 4-lamp T5 fixtures reduces the calculated energy savings by half.

Table 6. T5 for Metal Halide; when increasing fixture quantity

Replacement Fixture Type	400 Watt High Pressure Sodium	
	% of Existing Watts Saved	% of Tables Replacement Watts
4-lamp HO T5	50%	84%
6-lamp HO T5	25%	16%

HP T8's replacing T12s

Approximately 14% of electric savings from PE lighting measures came from instances of T12s being replaced with High Performance T8 fixtures. The majority of these, 87%, involved replacing the existing fixtures with an equal number, while 10% and 3% increased and decreased the number of fixtures used, respectively.

Table 7 below shows the percentage of measures with same fixture quantities where the lamps per fixture changed. When both the number of fixtures and the number of lamps per fixture are considered, approximately 20% of HP T8 replacements for T12s involve a reduction in the number of lamps used.

Table 7. Measures Involving HP T8 Fixtures Replacing an Equal Number of T12 Fixtures

Number of Lamps in Fixture Replacements	N	%
Increase in Number of Lamps	3	<1%
Same Number of Lamps	181	49%
Decrease in Number of Lamps	70	19%

The following graphs group the percentage of existing and replacement watts by technology over the last four years. Figure 1 and Figure 2 show the percent of replaced and replacement watts, respectively, by the most prominent technologies in a given year.

Figure 1.

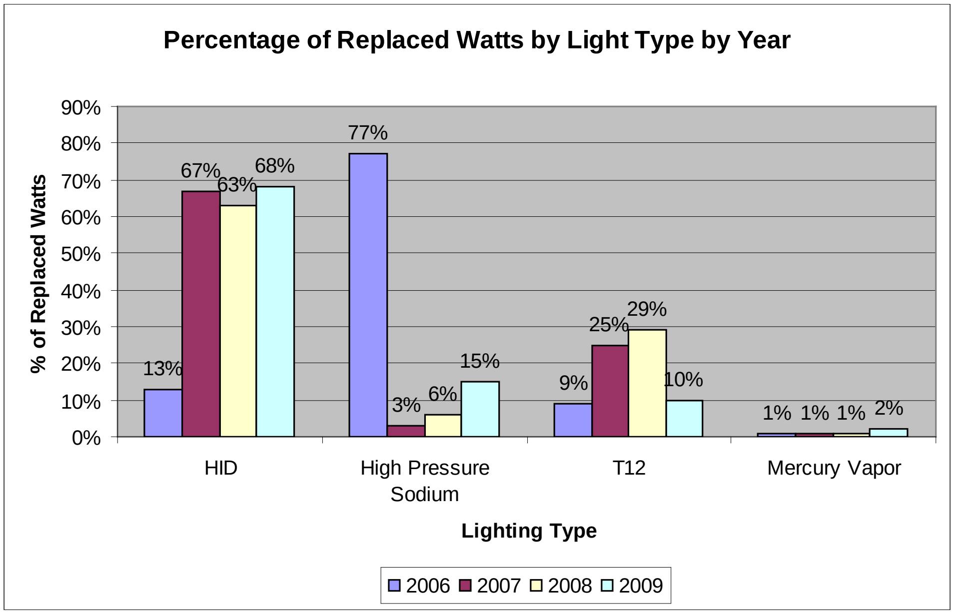
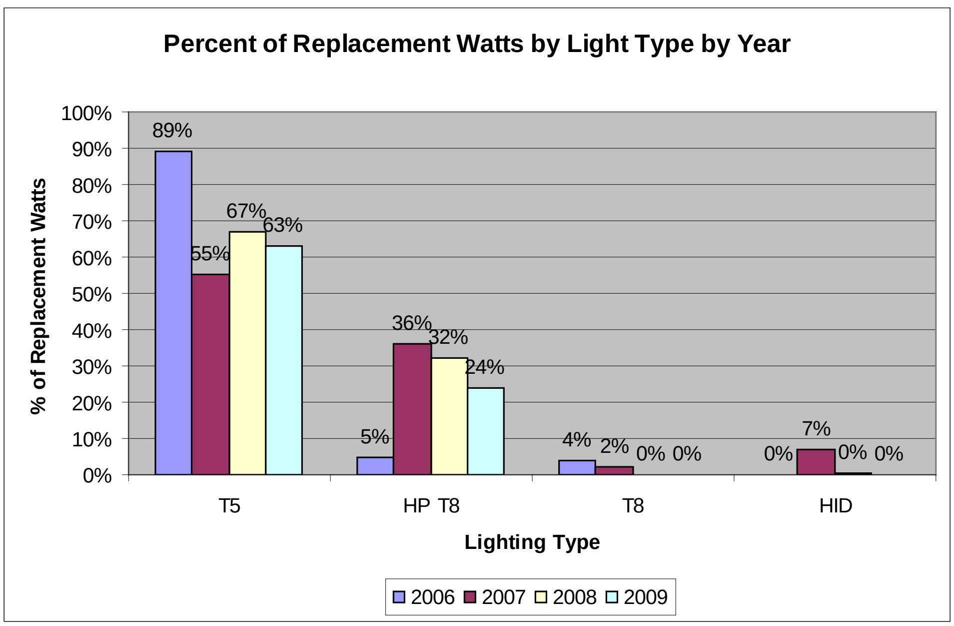


Figure 2.



Controls

Analysis of controls installed on industrial lighting fixtures through Energy Trust PE programs showed that almost 97% (of the 14,586 installed controls in the dataset) were fixture mounted occupancy sensors. Of these, 65% and 30% were installed on HO T5 fixtures and HP T8 fixtures, respectively.